REID

Tasmania

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BULLETIN

No. 32

Osmiridium in Tasmania

BY

A. McINTOSH REID, Assistant Government Geologist

Issued under the authority of

The Honourable Sir NEIL ELLIOTT LEWIS, K.C.M.G.
Minister for Mines for Tasmania

Tasmania:

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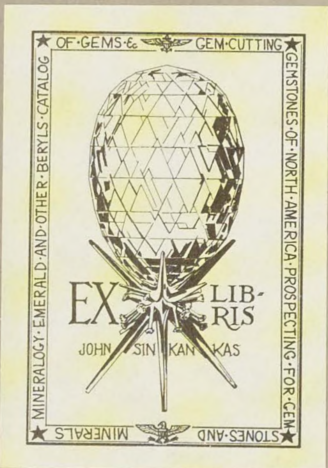
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Osmiridium in Tasmania.

SUMMARY.

At the present time the development of the osmiridium industry in Tasmania is almost entirely of a superficial character, attention being directed almost exclusively to concentrations in alluvial material. Although attempts have been made to extend exploration to the particular kind of serpentine rock in which the mineral was originally contained, the lack of knowledge regarding the true nature and origin of osmiridium deposits has led, in many instances, to much useless expenditure and the discouragement of the operators. In a few isolated cases, however, success has attended the efforts of some who have continued the search for rich deposits in the serpentine rock. The successful exploitation of both alluvial and rock deposits depends largely on the initiative possessed by the operators to apply the most suitable methods to the requirements of the particular case in hand. The peculiarities of these deposits—their erratic nature and distribution—and the consequent unique problems that they present in exploration and development, create such confusion of ideas that prospects are sometimes abandoned which, under more expert control, might have proved profitable enterprises.

It has been definitely established as the direct result of the recent investigations of the Tasmanian fields that the occurrence of osmiridium is intimately related to the chemical and physical characters of serpentine rocks derived largely from bronzite rich in alumina, consequently the distribution of this mineral is determined by that of a particular variety of serpentine. For instance, in all the fields the osmiridium invariably accompanies serpentinised peridotite (olivine and bronzite), while the serpentines derived from pyroxenites and gabbros are barren. It is noteworthy that in these peridotites all metallic elements other than those that occur in combination with silica are found in alloy with one another or uncombined with other elements. It has been determined also that the deposits of osmiridium in the peridotite serpentine are almost exclusively confined to pockety accumulations distributed irregularly along structural planes in the rock. These structural planes are sharply

marked and continuous, and their seeming regularity has given rise to the mistaken idea of the occurrence of these precious metals in vein or lode formations. It will be perceived from the foregoing that not only is it possible to distinguish the osmiridium-bearing serpentines from those that are barren and accurately delimit their boundaries, but the precise location of the deposits in these rocks can be fixed without difficulty. The practical considerations arising out of this discovery are evident.

Recent exploration and development have revealed enormous deposits of osmiridium- and gold-bearing gravels in the valleys of the larger rivers of the Western Division. The bulk of this material is of fine grain-size, but the proportion of "point metal" increases as the workings approach the parent serpentine. As already pointed out, the development of the rock formations will follow the advancement in knowledge of the peculiar features of these deposits, and the ability of operators to distinguish between peridotite serpentines and those derived from pyroxenites and gabbros. The best known rock-formations occur at Bald Hill, Mt. Stewart, and Wilson River. Those in Renison Bell and Dundas areas were not examined in detail owing to lack of time, and for the same reason no attempt was made to penetrate the almost inaccessible country north of Bald Hill. The deposits in the Gordon Division are small, comparatively poor, and difficult of access, and the northern field in the neighbourhood of Beaconsfield is not likely to become prominent.

Tasmania is in the happy position of being the sole producer on a large scale of "point metal" osmiridium, and there does not appear to be any likelihood of her position being challenged by foreign competitors for many years.

The proposed use of alloys, stated to be produced at half the cost and alleged to be satisfactory substitutes for osmiridium, and the reported discoveries of more important sources of supply in Papua, Japan, and Borneo may be regarded with equanimity, as there never has been such a strong demand as at present, and the continued advance in price can be interrupted only by the manipulation of the markets by speculators; in fact, the production of these metals is so far below the pre-war output and the requirements of all civilised countries are increasing so rapidly that it has been suggested that their distribution be placed under international control.

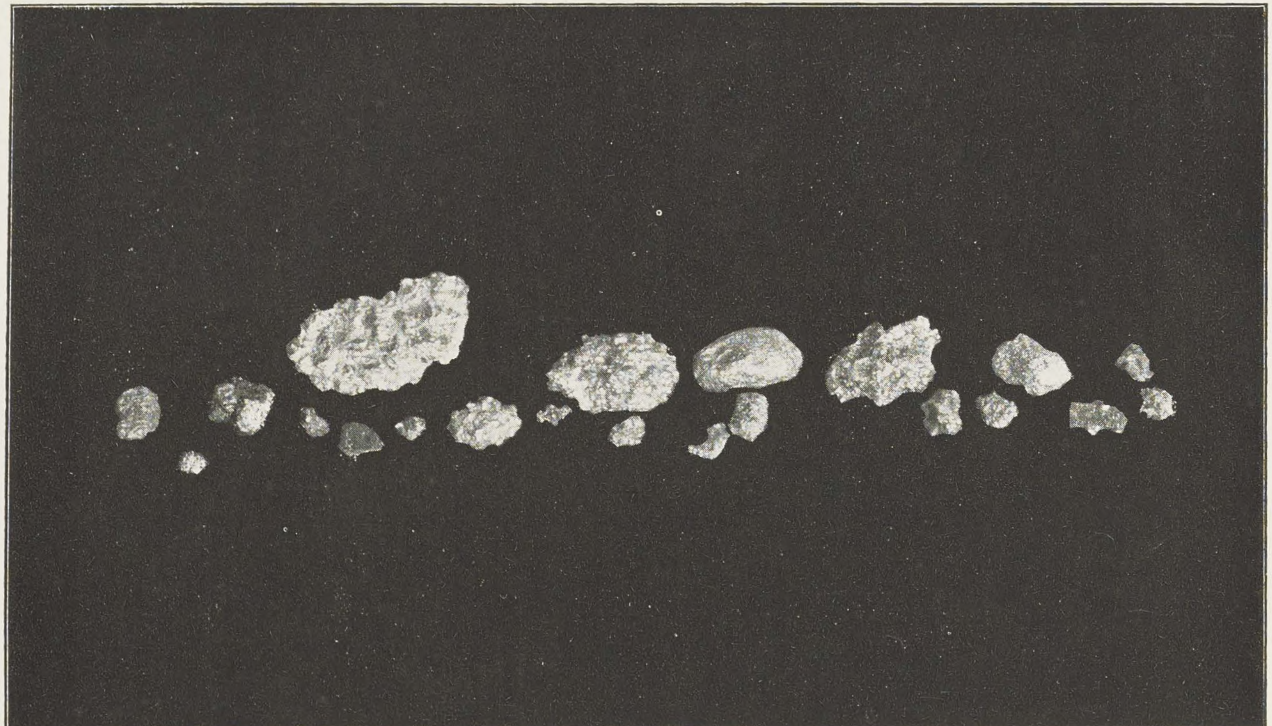

Photo. 1.—ASSORTED NUGGETS OF OSMIRIDIUM, NINETEEN-MILE CREEK. (Nat.) [*A. M. Reid, Photo.*

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INTRODUCTION.

Preliminary Statement.

Tasmania is, to-day, the largest producer of "free" osmiridium in the world. This pre-eminent position has been reached in quite recent years, and since 1910 phenomenal progress has been made in the development of the industry. An idea of the wonderful expansion in the production of the mineral may be gained by comparing the statistical returns for 1910 with those of succeeding years. During the war period there was a considerable slump in the market, and a corresponding fall in production, but since then the recovery and advancement have been extraordinarily rapid. This increase is primarily due to enhanced prices, following the great demand for the crystallised, course-grained "metal" found in commercial quantities only in Tasmania. The incentive thus given has so stimulated mining activity that remunerative employment is found for over 250 men.

Owing to the great interest manifested by the miners in the origin of this mineral, and the possibilities existing of exploiting the primary deposits, an endeavour has been made to determine the location of the rich segregations. In these investigations very important data have been gathered, which not only throw light on the obscure origin, and occurrence of this mineral, but, in addition, provide material information of economic value. These investigations have revealed the presence of "free" platinum in the osmiridium deposits, the magmatic origin of the gold, and the occurrence of diamond *in situ* in the olivine-bearing rocks of Bald Hill. The importance of these discoveries will be apparent when it is recognised that osmiridium, platinum, and diamond are genetically related, and the study of the origin of one will throw light on the conditions existing at the time of the formation of the others.

At the present time attention is directed particularly to the rich concentrations in alluvial and detrital deposits

derived from osmiridium-bearing serpentines. Many of these deposits are already seriously depleted of their mineral wealth, and the time is not distant when attention must be given to the parent rock for future supplies. Recognising this fact it becomes evident that a satisfacory knowledge of the origin and character of osmiridium are absolute essentials in considerations of the future. It is the aim of the writer in these pages to give an explanatory sketch with that object in view

General Statement.

This publication comprises reports on all the important osmiridium fields known in Tasmania. The several areas examined are grouped, for convenience of description, in three divisions, namely—the western, including the Heazlewood, Long Plain, Wilson River, Renison Bell, and Dundas fields; the Gordon (or Southern Division), including the Styx, Florentine, Spero, Birch's Inlet, Boyes and Hamilton Range areas; and the Northern Division, comprising the Salisbury goldfield.

On the locality map (Plate I.) the large outcrops of serpentine are shown by full black lines, and the positions of the several fields are indicated by numbers, thus—

No. 1	Heazlewood. Long Plain.	Western Division.
No. 2	Wilson River.	
No. 3	Renison Bell.	
No. 4	Dundas	
No. 5	Spero River.	Gordon or Southern Division.
No. 6	Hamilton Range.	
No. 7	Boyes' River.	
No. 8	Florentine River	
No. 9	Styx River.	
No. 10	Birch's Inlet.	
No. 11	Salisbury District.	Northern Division.

The investigation of the Western fields was made during the period extending from 8th November, 1919, to 8th March, 1920, and the Gordon, or Southern, fields between 7th May and 10th June, 1920.

ACKNOWLEDGMENTS.

The writer desires to express his appreciation of the courtesy and hospitality extended to him by the miners and prospectors residing in the districts visited by him. It is his wish to gratefully acknowledge also the indebtedness he feels to those who assisted him directly in the furtherance of this investigation. In particular, his thanks are due to Messrs. Selwyn Cox, for samples of residues and subjects for photographs; T. H. Jones, who supplied notes on the history of the fields; James Ramsay, for samples of osmiridium; Geo. Warner and Thomas Pursell, for general information relating to the Heazlewood district; and to Messrs. Martin Healey and Frederick Kershaw, who accompanied him on special trips to outlying areas.

The writer was accompanied on the expedition to the Western fields by Lieutenant J. Temple Riley, and to the Gordon (or Southern) fields by Mr. J. Innes, as field assistants. It is a pleasure to place on record the splendid and efficient services rendered by these gentlemen. Some of the long and arduous journeys were carried out under extremely trying conditions, yet they willingly set out and accomplished the work assigned to them.

Information relating to the occurrences of the platinum metals in their respective countries has been generously furnished by the Geological Survey Departments of the United States of America, Dutch East Indies, New South Wales, and Papua.

CHAPTER I.

Historical.

([1]) In 1803, in the operation of purifying platinum, Wollaston isolated a new metal, which he named palladium. The same year that palladium was discovered, Smithton Tennant, a British scientist, found that "the black powder which remained after the solution of platinum did not, as was generally believed, consist chiefly of plumbago, but contained some unknown metallic ingredients."([2]) In 1804 he announced the discovery of two new metals—iridium, named "from the striking variety of colours which it gives while dissolving in marine acid"; and osmium, so called because of the penetrating odour of the acid obtained from the oxidation of the element when it is heated in a finely-divided condition. Later it was found that these metals are habitually associated, and the alloy was named iridosmine, or osmiridium.([3]) A few days after Tennant's announcement Wollaston reported the discovery of an element in the "fluid which remains after the precipitation of platinum by ammonium chloride," and suggested the name "rhodium," from the rose colour of a dilute solution of the salts containing it.

([4]) In 1826 Osann claimed the discovery of three new elements in platinum alloys. These he named ruthenium, polinium, and pluranium. Later he withdrew the claim. In 1844 Clauss found that there was an unknown metal in the mixture of substances which had been called by Osann "ruthenium oxide," and for it he retained the name ruthenium, derived from Ruthenia, *i.e.*, Russia, where the substance was first found.

Chemical and Physical Properties of the Platinoid Metals.

Occurring almost invariably associated with platinum, and usually alloyed with it, the rare elements contained

([1]) Phil. Trans. Roy. Soc. (1803), XCIII., 290.
([2]) Phil. Trans. Roy. Soc. (1804), XCIV., 411.
([3]) Phil. Trans. Roy. Soc. (1804), XCIV., 419.
([4]) Amer. Jour. Sci., XLVIII., 401.

in the mineral osmiridium comprise the group of so-called platinum metals:—

Metal.	Symbol.	Atomic Weight.	Specific Gravity.	Centigrade Melting Point.
Ruthenium......	Ru.	101·7	12·26	1800°
Rhodium	Rh.	102·9	12·10	2000°
Palladium	Pd.	106·7	11 50	1500°
Osmium	Os.	190·9	22·48	2500°
Iridium	Ir.	193·1	22·42	2500°
Platinum	Pt.	195·2	21·50	1775°

It is seen that these metals may be divided according to their atomic weights into two groups of three each, and according to the periodic law they fall into the same series. Furthermore, these metals fall into the same vertical column as iron, nickel, and cobalt, which have similar properties, form similar compounds, and give similar reactions, and because of the conditions last mentioned they generally have a similar origin. Thus, the platinum metals are seldom found apart from one another, and iron, nickel, and cobalt are frequent associates. The latter, however, of much lower atomic weights, are relatively more abundant. All of these elements almost invariably accompany rocks low in silica, such as peridotites and pyroxenites. No explanation has been given heretofore for their preference for ultra-basic rocks, but this is largely due to relative solubilities.

Ruthenium.—This metal is found dark grey to black in colour, but in its purest form it resembles platinum. Like iridium, it is hard and brittle, and after osmium it is the least fusible metal of the group. Ruthenium undergoes oxidation more readily than the other members of the family, with the exception of osmium. Acids, or mixtures of acids, do not attack ruthenium; it is soluble, however, in aqueous solutions of alkali hypochlorites, and in a mixture of fused caustic potash and potassium nitrate.

Rhodium.—This is a white metal resembling aluminium in appearance, and is slightly less ductile than platinum. When pure it is practically insoluble in all acids, but when alloyed it may be dissolved in aqua regia. Of all the platinum metals rhodium is the most easily attacked by chlorine. It has the property of absorbing hydrogen.

Palladium.—A lustrous white metal with the physical characters of platinum. It is malleable and ductile, and is the most easily fused of the platinum group. It is commonly found in the metallic state, and sometimes in alloy with gold and silver. Palladium is dimorphous, and crystallises in the isometric or in the hexagonal system. One of the most striking properties of the metal is the facility with which it absorbs hydrogen. At the ordinary temperature it absorbs 376 volumes of the gas, and at a red heat 935 volumes; all the hydrogen is lost when heated in a vacuum. It is difficultly soluble in boiling hydrochloric and sulphuric acids, but is readily soluble in nitric acid and in aqua-regia.

Osmium.—A bluish metal, harder than glass, infusible in the oxyhydrogen flame, and the heaviest of all known solids. It is dimorphous crystallising in cubes or in rhombohedra which are insoluble in all acids. In the finely-divided condition, however, it is soluble in fuming nitric acid, and dissolves slowly in aqua-regia. At a temperature somewhat above the melting-point of zinc it undergoes oxidation, producing the volatile and highly poisonous tetroxide (osmic acid) OsO^4. This compound is volatile at 100° C.

Iridium.—This is a hard, white, lustrous, brittle, metal, resembling steel. It is malleable at red heat, and melts only in the oxyhydrogen flame. At a dull red heat it absorbs oxygen from the air, forming an unstable oxide, but this decomposes at a higher temperature, and there is no effective oxidation above 1140°. It is a powerful catalytic agent when finely divided. It is neither attacked by fused alkalis, nor by acids or mixtures of acids; even aqua-regia is without action on it. Fused potassium bisulphide, however, converts it into an insoluble oxide.

Platinum.—The most abundant and the most important member of this group is a tin-white element as soft as copper, and after gold and silver, is the most malleable of all metals. In mass it is infusible in the gas furnace, but can be melted in the oxyhydrogen flame, and it can be welded considerably below the melting-point. The metal does not undergo oxidation when heated in air or in oxygen, and is very resistant to the action of water and acids. Concentrated sulphuric acid attacks it very slightly above 200°, whilst aqua-regia dissolves it readily. Platinum forms easily fusible alloys, with many metals, such as lead; and

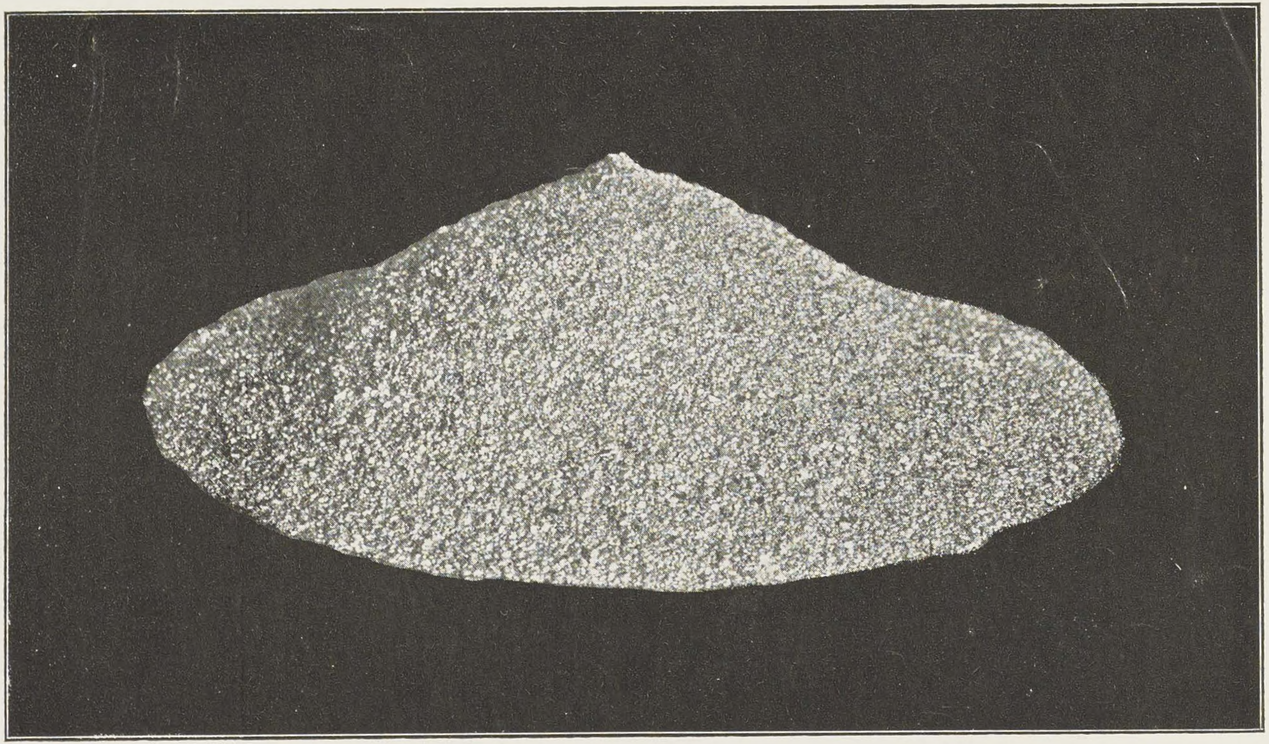

Photo. 2.—TYPICAL GRANULAR METAL FROM NINETEEN-MILE CREEK. [*A. M. Reid, Photo.*

Weight, 26 ounces. Value, £1092. (Nat.)

To face page 9.

these metals should not be heated in platinum vessels. The same caution applies to alkalis, cyanides, nitrates, charcoal, phosphorus, and arsenic.

Mineralogy of Osmiridium and the Associated Minerals.

Osmiridium, or (using its more euphonious synonym) iridosmine, is a native alloy, consisting essentially of the metals iridium and osmium in varying proportions. Two major varieties, depending on these proportions, have been named as species, but they are isomorphous, as are the metals themselves. Rhodium, ruthenium, and palladium, other members of the platinum group, are usually present, and when in appreciable amounts give rise to complicated and indefinite varieties. The two major varieties only are generally recognised—nevyanskite, containing over 40 per cent. of iridium; and siserskite, in which the iridium content is less than 40 per cent. Sometimes the name of the most prominent of the accessory constituents is prefixed in order to add further distinction. Thus are known ruthenium nevyanskite, rhodium nevyanskite, platinum nevyanskite, ruthenium siserskite, &c. This list might be extended by further subdivision, but the relative proportions are so indefinite that the increase in names would only result in confusion.

Nevyanskite is the familiar tin-white substance with a bright lustre so commonly met with in Tasmanian fields. It occurs in flat scales and in shotty form with the prism faces fairly well developed; also in crystal aggregates and in massive nuggets. The heaviest nuggets recorded from any part of the world have been found in the western Tasmanian fields. The official record of these is given in the subjoined table:—

Discoverer.	Weight—Troy.			Locality.
	ozs.	dwts.	grs.	
Gus. Nelson	2	8	8	Warner Creek, Heazlewood district
M. O'Malley	2	6	5	Warner Creek, Heazlewood district
Chas. Prouse	2	3	0	Nineteen-mile Creek, Heazlewood district
Jas. Sweeney	1	19	7¼	Sweeney Creek, Wilson River district

In addition to the foregoing, nuggets of the following weights were unearthed in the Heazlewood district during the year 1913.—

Oz.	dwt.	grn.	Oz.	dwt.	grn.	Oz.	dwt.	grn.
1	16	16	1	5	21	1	0	0
1	14	21	1	2	10	0	15	12
1	8	18	1	1	12	0	12	22

Many of the nuggets found here appear to be built up of crystallised particles, others are massive and cellular, while some are solid with rounded edges. The Sweeney nugget purchased by the State and exhibited in the Victoria Museum, Launceston, consists of clusters of crystals with interstitial chromite. These crystal aggregates are easily broken up into their constituent particles.

Siserskite is the dull, steel-gray to bluish-grey variety, and is comparatively rare. It occurs in the Mt. Stewart area from fine-grained particles to solid nuggets, some of which are angular and others are rounded. Commonly shotty material is found embedded and encased in large lumps of chromite, and the larger particles are usually coated with either chromite or limonite.

The specific gravity of siserskite is from 15·32 to 15·65.

Mineralogy of Osmiridium.

Crystallisation.—Rhombohedral, in hexagonal prisms.

Habit.—Usually in irregular, flattened grains or minute graphitic lamellæ; commonly in "shotty" form from very fine particles to rounded nuggets weighing over 2 oz.; also in large crystal aggregates.

Cleavage.— C perfect.

Hardness.—6 to 7, slightly malleable to nearly brittle.

Lustre.—Metallic, dull to splendent and glistening.

Colour.—Usually tin-white to light-grey, silver-white, bluish-grey and yellowish-grey.

Specific gravity—19·3 to 21·12 (nevyanskite), and 15·2 to 16·3, siserskite).

Aspect.—Opaque.

(5)

Axis $C = 1{\cdot}4105$; $0001 \wedge 10\bar{1}1 = 58^\circ\ 27'$ Rose

Forms: $c\ (0001, 0)$, $m\ (10\bar{1}0, I)$, $r\ (10\bar{1}1, R)^2$,

$z\ (01\bar{1}1, -I)^2$, $x\ (22\bar{4}3, \frac{4}{3} - 2)$

Angles: $cx = 62^\circ$, $rr' = 95^\circ\ 8'$, $xx' = 52^\circ\ 24'$

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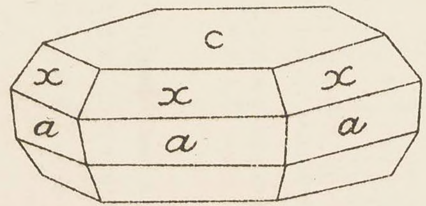
(5) Ed. S. Dana: "Text Book of Mineralogy."

PLATE II



The following selected analyses from foreign sources represent the great variation in the composition of native osmiridium:—

Locality—Russia. Authority—Hautpick.

Variety.	Iridium. %	Osmium. %	Rhodium. %	Ruthenium. %	Palladium. %	Platinum. %	Iron. %	Gold. %	Copper. %
Nevyanskite	77·2	21·0	0·5	0·2	...	1·1	0·1	...	0·4
Ditto	46·8	49·4	3·2	...	...	...	0·1	...	0·9
Ditto	43·9	48·9	1·7	4·7	...	0·2	0·6	...	1·1
Rhodium-Nevyanskite	70·4	17·2	12·3	...	...	0·1	...	...	...
Ditto	64·5	29·9	7·5	...	...	2·8	1·4	...	0·9
Platinum-Nevyanskite	58·2	27·3	1·8	5·9	...	10·1	...	...	trace
Ditto	55·2	27·3	1·5	...	trace	10·1	trace	...	trace
Ruthenium-Nevyanskite	43·3	40·1	5·7	8·5	...	0·6	0·99	...	0·78
Ditto	57·8	33·5	0·6	4·7	...	...	0·10	...	0·06

Locality—Colombia, South America.

Rhodium-Nevyanskite	70·4	17·2	12·3	...	0·1	0·1	...	...	...
Ruthenium-Nevyanskite	57·8	35·1	0·6	6·3	...	...	...	...	...

Locality—California, U.S.A.

Nevyanskite	53·5	43·4	2·6	0·5	...	...	...	...	...

Locality—Borneo.

Nevyanskite	58·3	38·9	2·6	...	...	0·2	...	...	...

A number of samples of osmiridium were submitted for examination to W. D. Reid, Government Assayer, who made the following observations:—No. 1 analysis included here was carried out in the laboratories of the Imperial Institute at the instance of the Agent-General for Tasmania, the late Sir John McCall.

No. 1.—A sample of loose metallic grains varying in colour from tin-white to yellowish-grey showed the following composition:—

		Per Cent.
Platinum	Pt.	0·37
Ruthenium...	Ru.	8·19
Palladium	Pd.	0·21
Iridium	Ir.	33·80
Rhodium	Rh.	
Osmium (by difference)	Os.	57·09
Gold	Au	0·04
Iron	Fe	0·30
Copper	Cu	Trace

No. 2.—A sample of similar material from Ball Hill yielded:—

	Per Cent.
Ruthenium	5·22
Iridium	58·13
Rhodium	3·04
Osmium	33·46
Copper	0·15

No. 3. Osmiridium, consisting of tin-white to lead-grey grains typical of the Mt. Stewart area contained:—

	Per Cent.
Platinum	0·13
Ruthenium	9·24
Palladium	Trace
Iridium	46·12
Osmium	25.22
Rhodium	4·37
Iron	6·30
Gold	3·00
Silica	3·71

A mineral, resembling amorphous sulphide of iron in appearance, consisting of minute grains of osmiridium mechanically involved with sulphides of iridium, osmium, and ruthenium, is commonly met with in the Mt. Stewart

area. The specific gravity varies with the osmiridium content from 6·80 upwards.

No. 4. Its approximate composition is illustrated in the following analysis:—

	Per Cent.
Iridium	41·70
Osmium	16·10
Ruthenium	7·87
Rhodium	0·45
Platinum	2·32
Palladium...	0·21
Iron	6·50
Gold	2·18
Silica	2·36
Sulphur	15·45

NOTE.—The discrepancy shown in the foregoing analysis is due to the impossibility of obtaining a uniform sample. It is probable also that portion of the iron component is contained as ferric oxide.

A close survey of these analyses shows that the iridium and osmium components preponedrate, and that the proportions of both vary greatly in the alloy. It will be noticed that a high iridium content is accompanied by a correspondingly low content of osmium, and *vice versa*.

Furthermore, the proportions of one to the other are in such precise terms as to suggest definite mineral species. For instance, the metals are most commonly alloyed in the proportions of 1 : 2, thus: Ir : 2 Os is the prevalent combination, but 2 Ir : Os is not infrequent. Alloys of iridium and osmium in the proportions of 1 : 1 and 4 : 1 are also known.

Rhodium and ruthenium are always present, the latter sometimes in appreciable proportion; and palladium and platinum, although fairly constant constituents, are generally quite subordinate. Gold, iron, and copper are frequently prominent, but in some samples are entirely lacking. The high content of iron in the Mt. Stewart alloy accounts for the low specific gravity of the mineral from this locality. In other respects the several metals occur in the usual proportions, and the high content of ruthenium in this mineral is not distinctive of the locality as generally supposed.

Associated Minerals.

Associated with osmiridium are certain minerals which are authigenetic with the parent basic rocks. Such are platinum, gold, diamond, chromite, magnetite, heazlewoodite, menaccanite, zaratite, and picotite. There are, however, many minerals unrelated to these formations which are found associated by accident of position with osmiridium. Some of these are quartz, zircon, garnet, cassiterite, bismuth, bismuthenite, monazite, galena, and chalcopyrite. These are derived from the acidic portion of the original magma as represented by granites and granite porphyries.

Platinum.—This metal, with other members of the same group, such as iridium, ruthenium, and platiniridium, had been repeatedly reported heretofore, but the specimens submitted for identification proved in all cases to be varieties of osmiridium. The apparent absence of platinum in the Tasmanian deposits was regarded as a most singular phenomenon, as in other countries this member of the group invariably predominates. Analyses of Tasmanian osmiridium reveal an extremely varied constitution, but the platinum content is never pronounced, and is generally insignificant. The writer during his investigations of these fields obtained several small specimens of free platinum. In all cases this metal was attached to gold. This extraordinary mode of occurrence has been observed also in the Borneo deposits. The small flakes consist of gold on one side and platinum on the other, or one half is platinum and the other gold. This discovery is very interesting, not only because its occurrence has been definitely established, but also because it provides further evidence of the magmatic origin of the gold.

Gold.—No feature stands out more prominently in connection with these deposits than the constant association of gold with osmiridium. This association is not accidental, for not only is gold found here in the free state, but also, though in a minor degree, alloyed with osmiridium. It is, moreover, found much entangled with this mineral filling cavities in the larger nuggets. The metal occurs along structural planes in the serpentine between joints or walls a few inches apart. The serpentine is foliated and fibrous in character, and the gold occurs between the folia in flakes up to an inch in length. Commonly the nuggets are pear-shaped, but ovoid and elliptical forms are not infrequently met with. Some pieces are

flat and smooth, others have rough and even jagged surfaces. Gold is found associated with osmiridium in various sizes from minute irregular grains, thin scales to nuggets weighing several ounces. The proportions of gold to osmiridium is usually 1 : 2 to 1 : 3, but the ratio varies greatly in different localities. In some places the variation ranges from 1 : 8 to 1 : 1; in others the proportion of gold is very small.

In the native osmiridium alloy the gold content is fairly constant, but it never becomes prominent, and rarely exceeds 3·00 per cent.

It may be mentioned that gold alloys directly with individual members of the platinum group of metals. Thus, porpezite (palladium-gold) and rhodite (rhodium-gold) are found native in platiniferous sands in Brazil. An analysis of the magmatic gold from Bald Hill by W. D. Reid, Government Assayer, shows that it consists of 95 per cent. gold and 5 per cent. silver.

Diamond.—A few small diamonds have been obtained from gold- and osmiridium-bearing wash in the neighbourhood of Mt. Donaldson, near Corinna. Some have been recovered from Badger Creek and others from Harvey Creek. These gemstones have a light yellow tinge at the apices, and are found in octahedral form from one-eighth to one-third of a carat in weight.

Much interest has been manifested in the origin of these diamonds, and also the origin of the gold and osmiridium in that locality, which probably were derived from the same source. It was generally believed that they all originated in the Heazlewood serpentines, but no positive evidence had been put forward in favour of this supposition up to the time of this investigation. Although alluvial mining has been carried on in the Heazlewood district for a number of years, no loose diamonds have been found there, nor have any been found anywhere on the east side of Savage River. Perhaps this may be accounted for by the fact that the attention of the osmiridium diggers is concentrated on the recovery of that metal, and they are less observant than L. Harvey, T. Batty, and Lawson, who discovered the diamonds in the Mt. Donaldson area. The country-rocks in that neighbourhood consist of slates, sandstones, and conglomerates of Pre-Silurian age, and no serpentine is known there A microscopical examination of slides cut from olivine-bearing rocks (peridotite) of Bald Hill shows the presence of diamond. This discovery

of diamond in the parent rock, interesting though it be, does not set all doubt aside as to the origin of the stones found on Badger Plain. It is possible that in the course of alluvial mining in the Heazlewood district diamonds have been overlooked and discarded, and probably a more careful examination of the pannings may result in some being found there; but in any case, it is not anticipated that they will be found in plenty. However, it may pay osmiridium diggers to become more observant than formerly, in order to obtain another marketable product from the gravels.

It is noteworthy that diamonds have been detected in the gemsands of Hellyer River, where also osmiridium has been found. These minerals, in all liklihood, were derived from ultra-basic rocks exposed in that locality.

Between Long Plain and Hellyer River there is a large tract of unexplored country which may be the secret source of the diamonds found in these localities.

Chromite.—Chromite is an oxide of iron and chromium ($Fe\ Cr_2\ O_4$), but with variable replacements of Fe^{11} by Mg. and of Cr. by Al. and Fe^{111} as in the other members of the spinel group. When pure it contains 68 per cent. of chromium sesquioxide (Cr_2O_3). It is a black, fairly hard ($H = 5{\cdot}5$) mineral crystallising in the isometric system, usually in octahedra; it possesses a sub-metallic to metallic lustre, and is so comparatively light (Sp. G = 4·3 to 4·6) that it can be separated easily from the heavy precious metals with which it is associated.

Chromite occurs in peridotite as an accessory constituent of the rock. It is found in small grains scattered through the peridotite, sometimes with idiomorphic outlines, but generally in crystalline irregularly-shaped blebs. It occurs also in the form of " schlieren " filling planes developed in the rock during cooling and consolidation. As such it is a basic segregation of the peridotite magma, and was formed contemporaneously with the osmiridium. Many large pieces of chromite extracted from such joints in the rock were found to contain small scales and pellets of osmiridium mechanically involved in its mass. Some specimens are so rich that the content of osmiridium amounts to as much as 30 per cent.

Picotite (Chrome Spinel).—By the reduction of the iron and chromium content of chromite and their partial replacement by magnesium and aluminium, the mineral picotite is developed. This mineral ($(Mg\ Fe)\ O\ (Al\ Cr)_2O_3$,

lies between chromite and spinel proper. It is a hard ($H = 8$) mineral, lighter than chromite (Sp. G. = 3.5 to 4.1), and like the latter crystallises in the isometric system, commonly in perfectly-formed octahedra. It has vitreous lustre, and is black in colour. Unlike chromite it commonly occurs in pyroxenites, and rarely in rocks rich in olivine. The development of this mineral is due to the presence of aluminium in the basic magma,

It is frequently mistaken for chromite because of the similarity in appearance and crystallisation. Its distribution is very wide occurring, as it does in all the streams in the Heazlewood district, and, in particularly rich concentrations, east of Mt. Jasper mill. In the pyroxenites it is found in individual crystals scattered through the rock-mass and in gabbros it is particularly abundant.

Magnetite.—Magnetite is the magnetic oxide of iron. Its composition is Fe_3O_4, with variable replacements and impurities. In many respects this mineral bears a resemblance to chromite, possessing an equal hardness (5·5), black colour, metallic lustre, and isometric crystallisation, but it is much heavier (Sp. G. = 5·17), and is strongly magnetic. It commonly occurs as an original constituent of the pyroxenites, in which case it is found in irregularly-shaped blebs scattered through the rock. The occurrence of magnetite in pyroxenite magmas is analagous to that of chromite in peridotite. As a secondary mineral it is formed by the decomposition of olivine and pyroxene. The primary deposits are due to segregations in the pyroxenite magma.

Nowhere in the osmiridium-bearing formations is it found in commercial quantities, but in the older gabbro-amphibolite formations in Long Plain district enormous concentrations occur.

Menaccanite or Ilmenite, a titanic oxide of iron, with sometimes a little magnesium replacing the ferrous iron. The normal composition is FeO, TiO_2 and the crystallisation rhombohedral. The hardness is 5 to 6, specific gravity 4·5 to 5, colour iron-black, and the lustre is sub-metallic. With chromite, picotite, and magnetite, this mineral forms a fairly large proportion of the river sands derived from the disintegration of serpentine. It is, however, much less abundant than its associates, and in some places is entirely absent. It occurs as an accessory component in pyroxenite rocks in small grains, assuming the place of

magnetite, especially in the gabbros. Like the others, it is a primary constituent of the basic rocks, in which it is sparsely disseminated.

Limonite.—Limonite has no crystallisation of its own, but is frequently found pseudomorphous after other minerals, such as pyrite. The composition of limonite is 2 $Fe_2\ O_3\ H_2O$, with many impurities. The specific gravity is 3·6 to 4·0, the harness 5 to 5.5, and the colour various shades of brown. It occurs in very great abundance in the form of superficial residual deposits resulting from the decomposition of ferromagnesian minerals during the conversion of the magnesian component into serpentine. Such deposits were regarded by the uninitiated as the cappings of lodes, and much useless expenditure on exploratory works resulted.

Heazlewoodite.—This is a distinct variety of nickel ore occurring in the Heazlewood district. It differs from pentlandite and its congeners in several important particulars. It is a yellowish-bronze mineral, having a metallic lustre and light bronze streak. The specific gravity has been determined as 4·61, and the hardness about 5. It is highly magnetic. The mineral occurs in narrow bands up to 3 inches wide in serpentine rock. A complete analysis has not been made, but samples have shown a nickel content up to 38 per cent.

Zaratite.—Heazlewoodite alters readily into zaratite, which is a constant associate in the Heazlewood district. Zaratite is an emerald-green carbonate of nickel occurring as thin coatings and incrustations on Heazlewoodite and serpentine at the Lady Brassey Mine. Although containing 59·6 per cent. of nickel protoxide, it is too uncommon in nature to be of any commercial importance as an ore of the metal.

Mineralogy of Rock-forming Minerals.

Pyroxene.—An important family of ferro-magnesian rock-forming minerals which are well represented in the basic igneous rocks of the areas under discussion. The several varieties occurring here may be divided into two definite groups according to their crystallisation, viz.:—

(1) Rhombic—

Enstatite	...	$Mg\ SiO_3$, with less than 5 °/$_o$ Fe O
Bronzite	...	$(Mg\ Fe)\ SiO_3$, with 5 to 14 °/$_o$ Fe O
Hypersthene		$(Fe\ Mg)\ SiO_3$, with more than 14 °/$_o$ Fe O.

(2) Monoclinic—

Diopside ...	$Ca\ Mg\ (SiO_3)_2$ / $Ca\ (Mg\ Fe)\ (SiO_3)_2$	Non-aluminous.
Hedenbergite	$Ca\ Fe\ (SiO_3)_2$	
Augite... ...	$Ca\ (Mg\ Fe)\ (SiO_3)_2$ with $(Mg\ Fe)\ (Al.\ Fe)_2\ SiO_6$	with alumina.

The rhombic pyroxenes, especially the enstatite variety, are the predominant constituents of the basic rocks represented in these districts. Enstatite and bronzite are very common constituents of peridotites and the serpentines derived from them; hypersthene is less common. Augite and diallage occur both as rock-masses and as constituents, with other minerals of various ultra-basic or femic rocks.

Amphibole.—The species of the amphibole group are chemically allied to the pyroxenes, but differ in the angular measurement, their cleavage, and their larger and more blade-like habit. The group, although so closely related to the pyroxenes, is less numerous in species, and the members show less variety of form. They nearly all crystallise in the monoclinic system, and occur generally irregularly aggregated, but may be fibrous or columnar in growth. In lustre they are vitreous to pearly on cleavage faces, opaque to translucent, and when massive extremely tough. They may be divided thus:—

(1) With little or no aluminium—
Actinolite.
Asbestos.
Tremolite.

(2) Containing aluminium—
Pergasite or common hornblende.

Actinolite is a green-coloured fibrous variety of amphibole occurring usually in long slender prisms of the monoclinic system. It also occurs in large radiating aggregates of fibrous habit. At Heazlewood it is found in radiating acicular bunches, and at the 14-mile peg in dense rock-masses; at Whyte River, near the base of the Meredith Range, and at various points in Savage River area, it is found in its common fibrous form. Asbestos of the common white variety, with mountain cork, occurs in Mt. Stewart area and in other parts of Heazlewood district.

Tremolite, resulting from alteration of pyroxene, in white compact forms, occurs in veinlets at the Brassey Mine, Heazlewood Bridge, and in small quantities in many other places.

Pergasite or hornblende is a dark-green to black mineral occurring in stout lustrous crystals in fairly large rock-masses or in granular form as a constituent of other rocks. At the Heazlewood an extensive mass occurs in acicular crystals intermixed with chlorite, forming an almost solid compact rock of a pale asparagus-green colour. It occurs also in stout crystals as a constituent of gabbro-amphibolite in Huskisson River area and at Renison Bell.

Olivine or Chrysolite.—A yellowish-green mineral of vitreous lustre, crystallising in the orthorhombic system, and consisting essentially of magnesium-iron silicate $(Mg\ Fe)_2\ SiO_4$.

This mineral is a most important component of ultra-basic rocks, increasing in amount until it constitutes the whole rock, as in the dunites. In rock form it is one of the hosts of the platinum metals, gold, chromite, and diamond, found in these districts.

It is an important constituent also of the olivine basalts of this region.

This mineral alters readily into serpentine, and from this origin are the large masses of that rock partly derived.

Serpentine.—Serpentine, the mother rock of osmiridium and its associates, occurs here in very large rock-masses in all shades of colour from white, yellow, green, brown to black, but most commonly yellowish-green. The lustre is resin-like or waxy, and it is smooth and sometimes greasy to the touch. It has no distinctive crystallisation of its own, but is found pseudomorphous after other minerals.

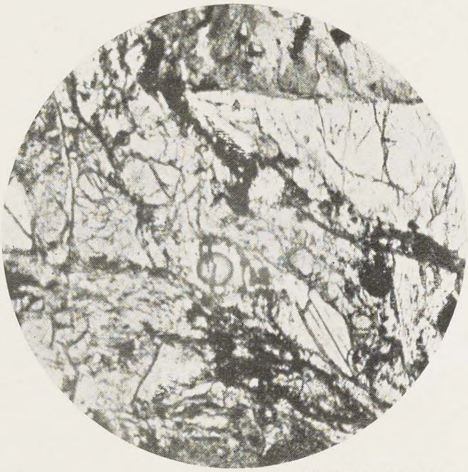
Its many forms have been separated into species according to differences in structure; thus are known massive, slaty, foliated, and fibrous varieties, and these have received certain distinctive names.

Serpentine occurs: in crystal pseudomorphic form as bastite; massive as noble serpentine, common serpentine, and resinous; lamellar as antigorite; thin foliated as marmolite; and fibrous as chrysotile and picrolite.

Microscopic examination has established the fact that serpentine in rock-masses has been largely produced by the alteration of olivine and pyroxene and in a lesser degree of amphibole.

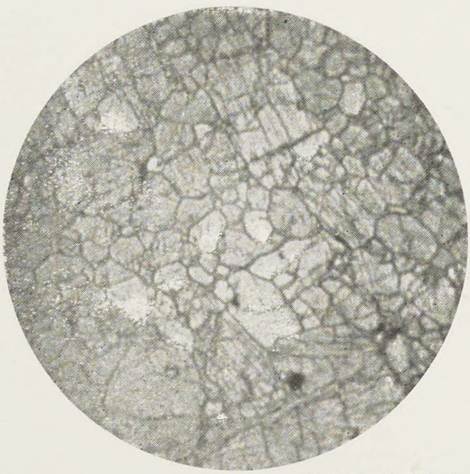
Its composition is hydrous silicate of magnesium $3\ Mg\ O\ 2\ SiO_2\ 2\ H_2O$ = silica 44·1, magnesia 43·0, water 12·9. Iron protoxide often replaces a small part of the magnesium.

All of these varieties of serpentine occur in the osmiridium areas in the form of rock-masses.



[*A. M. Reid, Photo.*

Photo. 3.—Photomicrograph of Pyroxenite.
(Crossed Nicols.)



[*A. M. Reid, Photo.*

Photo. 3.—Photomicrograph of Pyroxenite.
(Crossed Nicols.)

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Petrology.

The plutonic formations responsible for the osmiridium deposits constitute a most extraordinary assemblage of sub silicic rocks. The many varieties occurring here represent the several phases of rock differentiation from the original, more or less homogeneous magma. In addition to the sub-silicic or femic, the extremely silicic or salic representatives of the stock magma occur, and these also will be referred to in some detail.

In order to facilitate description it has been found convenient to separate these formations into two divisions namely, the femic and the salic.

THE FEMIC (FERROMAGNESIAN) DIVISION.

Peridotite Series.

Dunite (olivine) $\left\{\begin{array}{l}\text{forsterite, } Mg_2\ SiO_4. \\ \text{fayalite, } Fe_2\ SiO_4.\end{array}\right.$

Harzburgite (enstatite + olivine).

Picrite (olivine + augite).

Lherzolite (diallage + enstatite + olivine).

Wehrlite (olivine + diallage).

Olivine is the intermediate member of an isomorphous group of minerals including:—

Forsterite—rich in magnesium. Mg_2SiO_4.

Olivine—$(MgFe)_2SiO_4$.

Fayalite—rich in iron. Fe_2SiO_4.

Usually forsterite and fayalite occur in isomorphous mixture in which the magnesium salt generally predominates. Rocks consisting wholly of olivine are called dunites, and in these some of the rich deposits of osmiridium are found. The members of the olivine group all alter readily into serpentine, consequently seldom are fresh rocks of this group found in nature. The serpentines derived from them are light-yellowish to dark-green in colour. They have a waxy lustre and greasy feel, and can be distinguished with ease in the field.

The dunites occur on the north-western fall of Bald Hill, at the upper end of Loughnan Creek in the Mt. Stewart area, and in the vicinity of Riley Knob, Riley Creek, and Ahearne Creek in the Wilson River district. The Bald Hill body of dunite and peridotite is bounded on the north-west by Nineteen-Mile Creek, and extends from McGinty to Jones Creek. The rock is generally well exposed, but covered in places by a thin mantle of serpentinous soil.

Under the microscope it is seen to consist of a felted mass of serpentine with secondary magnetite, and is studded with idiomorphic crystals of chromite. In not all cases, however, has the alteration been so complete, and the outlines of the olivine crystals can be distinctly perceived in some specimens.

A sample of peridotite from Riley Creek, Wilson River district, analysed by W. D. Reid in the Geological Survey Laboratories, contained:—

	Per Cent.
Silica (SiO_2)	35·39
Magnesia (MgO)	25·32
Lime (CaO)	Trace
Alumina (Al_2O_3)	16·71
Ferrous (Feo) / Ferric oxide (Fe_2O_3)	9·54
Water (H_2O)	12·44

This rock is completely serpentinised. The high proportion of alumina is due in a measure to concentration by the dissolution of the soluble component, and in part to the presence of much bronzite.

A similar rock from Caudry's Prospect, Bald Hill, contains:—

	Per Cent.
Silica	33·56
Magnesia	17·81
Lime	Nil
Ferric oxide	10·71
Alumina	20·94
Water	14·84

Bronzite is a very prominent component of this rock. The high alumina content of the bronzite is extraordinary, and seems peculiar to the osmiridium-bearing rocks.

The peridotitic rock harzburgite consists of olivine and enstatite—both orthorhombic minerals. Microscopical examinations of specimens from the Bald Hill show this rock to consist of fairly fresh enstatite set in dark serpentinised olivine. The olivine exhibits the usual mesh-like arrangement of decomposition lines sharply outlined by chromite and secondary magnetite. In some cases complete alteration has ensued, and such minerals as talc, magnesite, and chlorite have been developed. In thin section the specimens taken show varying degrees of alteration to serpentine, and none shows fresh olivine. In extreme cases both the olivine and enstatite have been converted into serpentine.

The hard rock on the road near the 19-mile is a dark mottled harzburgite, considerably serpentinised and containing a good deal of magnetite. The higher coloured mineral is enstatite, and the darker patches are serpentinised olivine. Alteration has commenced in minute cracks in the crystals of olivine and pyroxene, and gradually the original minerals have been decomposed into serpentine and magnetite. Marking the transition stage between peridotites proper and pyroxenites are three olivine-bearing rocks containing monoclinic pyroxene. Picrite and wehrlite are uncommon and may be regarded as extraordinary occurrences here. Lherzolite is found bordering the peridotites on Bald Hill and elsewhere; in fact, this combination is fairly abundant. The diallage and enstatite are fresh, and the olivine shows only incipient serpentinisation. Near the junction of Wilson and Harman Rivers a similar variety of the peridotites is found. Microscopically it appears to consist of plates of greenish pyroxene, with included chromite in a serpentine setting(6). L. L. Waterhouse, who examined this rock, makes the following observations:—"Microscopically the rock is seen to consist largely of rhombic pyroxene (bronzite), with some monoclinic pyroxene (diallage), a little olivine, serpentine, and chromite. The rock is holocrystalline, grain-size being variable, individual plates and crystals being medium to coarse. The bronzite is hypidiomorphic, and in some instances idiomorphic, while the diallage is generally allotriomorphic. Olivine is present in small residual grains with a little serpentine, alteration to the latter mineral being almost complete. The chromite is idiomorphic and has evidently been the first mineral to crystallise out from the magma, while the rhombic is evidently older than the monoclinic pyroxene."

The rocks of the peridotite group show varying degrees of alteration to serpentine, governed largely according to the proportion of olivine present. Here this secondary rock mineral is represented in all its phases. In colour the various shades of green predominate, from a very light greenish-yellow through greyish-green to a deep greenish-black. The extremely light-coloured varieties indicate that the original mineral consisted essentially of magnesium silicates; the others indicate an increasing iron content. The serpentine is frequently traversed by veinlets of chrysotile asbestos, from minute to one-inch fibre. In these

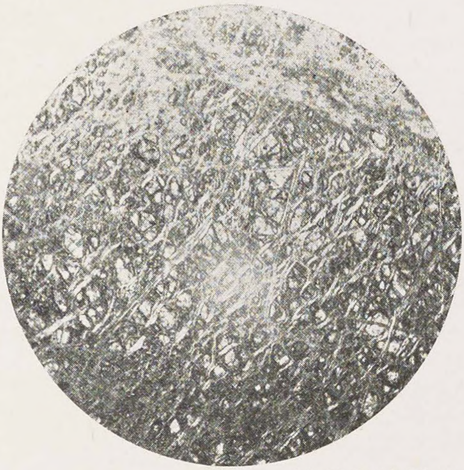
(6) L. Lawry Waterhouse, B.E., Tas. Geol. Surv. Bull. 15, p. 21.

the chrysotile is of the cross-vein type, the common habit of this mineral. Chrysotile occurs in the Heazlewood and in the Wilson district, the latter deposits being of considerable size. One such extends along the southern bank of Limestone Creek, across Wilson River, and along the northern flank of Websterite Hill. It has been noted at various points between Wilson and Harman Rivers. The splintery variety of serpentine known as picrolite has been observed in Nineteen-Mile Creek Valley. The mineral is a light-green in colour and smooth on unbroken surfaces. The fibres are brittle and coarse, and exhibit parallel-vein structure, indicating deposition lengthwise with the walls. A further stage in the metamorphism of these rocks results in the formation of steatite and talc. Steatite constitutes a considerable portion of the "clayey" material found at surface and in the joints and planes developed in the serpentine. At Mt. Stewart a vein 2 to 3 feet wide of very pure crystallised talc has been exposed in trenches and traced for several hundred feet. It is massive, compact in structure, of a beautiful pale sea-green colour, with a shining lustre and extremely unctuous feel. Smaller bodies have been developed in the serpentine near Ramsay and Caudry's prospect. Here it varies from a beautiful semi-transparent form to a translucent white and pale green. Brucite and schillerspar also occur as secondary minerals. Much of the serpentine often contains large quantities of minute, intensely black, octahedral crystals of chrome spinel (picotite) and chromite, the latter generally in small octahedra, but sometimes in large amorphous bunches in the form of "schlieren."

At the Heazlewood and vicinity the serpentine frequently contains a perceptible amount of nickel silicate, which gives it a bright apple-green colour, in which case it approaches that worked in New Caledonia as an ore of nickel.

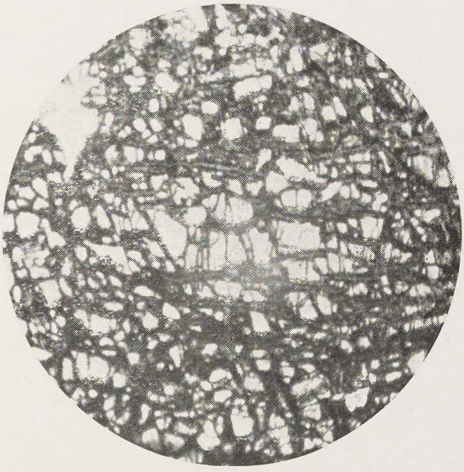
An analysis made by W. D. Reid in the Geological Survey Laboratories, of dark-green serpentinised peridotite from Bald Hill showed the following composition:—

	Per Cent.
Silica (SiO_2)	36·60
Magnesia (MgO)	12·31
Lime (CaO)	1·42
Alumina (Al_2O_3)	19·89
Ferric oxide (Fe_2O_3 + FeO) } Ferrous oxide ... ... }	19·51
Water (H_2O)	10·38



[*A. M. Reid, Photo.*

Photo. 4.—Photomicrographs of Peridotite.
(Crossed Nicols.)



[*A. M. Reid, Photo.*

Photo. 4.—Photomicrographs of Peridotite.
(Crossed Nicols.)

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As the rock is completely serpentinised it is difficult to arrive at its original constitution. Under the microscope much secondary magnetite is present and chrysotile is detected. The presence of lime and so much alumina indicates a monoclinic pyroxene constituent. The high percentage of alumina is probably due to concentration during serpentinisation and the solution of certain original components.

Pyroxenites Series.

Diallagite (diallage).
Websterite (enstatite + diallage).
Bronzitite (bronzite).
Websterite-porphyrite (enstatite + diallage).

The peridotite passes by almost imperceptible gradations into pyroxenite, many varieties of which occur here. The several varieties are developed from point to point in some cases consisting wholly of orthorhombic or of monoclinic pyroxene, in others of both. The most basic pyroxenite outcrops near the 18-mile, and, megascopically, appears to be composed of lustrous, dark-brown pyroxene, coated with a thin film of limonite. In thin section it is seen that the rock consists solely of orthorhombic pyroxene, the extinction being parallel with and perpendicular to the longitudinal cleavage direction. This pyroxene is a pale bronzite, with a scarcely perceptible pleochroism.

A similar rock shows up northward on Bald Hill. It is a dark, granular rock, composed wholly of bronzite in glistening crystals. The pyroxene is largely converted into bastite, and contains only small grains of olivine.

South of the 14-mile peg near some old workings is a nickel-stained pyroxenite composed of crystals in both the orthorhombic and monoclinic systems. These are distinguished by the straight extinction and lower interference colours of the rhombic pyroxene. The enstatite is undergoing alteration into bastite. Between the more perfectly preserved crystals the interstitial material consists of serpentine, chlorite, and talc.

At the extreme north-east corner of the Bald Hill outcrop of femic rocks, and on the north side of Jones' Creek, is a very large mass of bronzitite in the form of a hill rising 600 feet above the general level. The rock mineral is very coarsely crystalline, and possesses an adamantine-pearly lustre and olive-green colour. In it are found blebs, streaks, and irregularly-shaped bunches of magnetite

and, more rarely, chromite. An analysis by W. D. Reid, in the Geological Survey Laboratories, of a clean piece of this rock showed the composition to be:—

	Per Cent.
SiO_2	55·16
Mgo...	28·05
FeO...	10·70
Al_2O_3	3·50
CaO	Nil

Similar, but much smaller, coarsely crystalline masses occur at Mt. Stewart and Wilson River areas.

The Gabbro Series.

Gabbro (plagioclase + diallage + augite).
Norite (plagioclase + enstatite).
Gabbro-amphibolite (plagioclase + hornblende).

The gabbros, which consist essentially of plagioclase felspar and pyroxene (monoclinic, as augite or diallage; orthorhombic as enstatite, bronzite, or hypersthene), are the granitoid equivalents of basalts and diabases. Basalt is the volcanic member and diabase the intrusive member of the group. The felspar component of gabbro is always basic, such as anorthite, bytownite,or labradorite, the last most commonly represented here. As the gabbros have generally succumbed to decomposing agencies, it is difficult to find fresh specimens.

In the Heazlewood district there is a large body of a particularly handsome gabbro extending from Fenton's track north-eastward to Jones' Creek. The plagioclase (labradorite) felspar has been converted into milk-white saussurite, from which the dark, partly uralitised pyroxene stands out in contrast. The pyroxene is monoclinic diallage, and occurs generally in allotriomorphic form, indicating almost contemporaneous crystallisation with the labradorite, which is also without crystal outline. The constituent minerals are equidimentional, and of coarse, granular texture. No olivine appears in the thin section, but idiomorphic crystals of the accessory minerals, chromite and magnetite, are common. Other varieties occurring on the east side and south near the Mt. Jasper mine are of much finer grainsize, and have suffered lesser alteration. Under the microscope the rock appears holocrystalline, with poikilitic texture, the pyroxene enclosing idiomorphic labradorite. Incipient uraliti-

sation of the pyroxene is perceived, and the felspar is found to be almost completely altered into saussurite. In this rock the accessory oxides crystallised first,, followed by the felspar and the pyroxene in that order.

On the east side of Huskisson River, near the Great Bend, is a rock of very coarse grainsize, consisting of hypidiomorphic crystals of augite set in saussuritised felspar. The augite occurs in long plates up to 1 inch in length, and is remarkably fresh in appearance.

Near Mt. Jasper Mining Company's mill at Heazlewood is a variety consisting of long, bladed, idiomorphic crystals of diallage set in saussuritised felspar. In parts the diallage crystals are closely packed together when hypidiomorphic forms are developed, and there is in the rock as a whole a definite directional arrangement of crystals in lines parallel to the main structural plane.

At the lower end of Jones' Creek are fine-grained fresh-looking gabbros, consisting of equi-dimensional crystals of hornblende encased in partially altered plagioclase felspar. Small magnetite crystals are scattered through the rock.

SALIC DIVISION.

The rocks belonging to this division, consisting of granite, granite-porphyry, aplite, and quartz tourmaline, form the bulk of Meredith Range.

The light-coloured, biotite variety of granite constitutes the larger portion of this great mass, and generally it is of a remarkably uniform composition and texture. In their order of relative abundance the component minerals are orthoclase, plagioclase, quartz, and biotite. Orthoclase is the predominating mineral, and occurs in white, sometimes idiomorphic crystals. Plagioclase is not conspicuous to the unaided eye, but under the microscope it is seen to constitute a large portion of the rock. Biotite, in medium-size individuals, is scattered indiscriminately through the rock and pellucid quartz in relatively large crystals is prominent.

Granite of similar constitution, but of finer grainsize, and with equidimentional minerals, is a fairly common variant from the normal type.

At the Mt. Stewart galena mine a narrow dyke of quartz-porphyry juts out into the serpentinised femic formations. This rock has been rendered schistose, and completely transformed by the enormous pressure developed as the result of the conversion of the enclosing pyroxenites

into serpentines. The alteration is so profound that the schists are with difficulty recognised as metamorphosed porphyries.

Completely penetrating the serpentine at Mt. Stewart, and extending well into the granite, is a narrow dyke of quartz-tourmaline. Similar dykes, representing the final phases of differentiation, have been observed in other parts of the district.

METAMORPHISM.

The Serpentinisation of Femic or Ultra-basic Rocks.

A typical production of serpentine is from rocks containing olivine. It commonly results from the action of carbonic acid solutions on peridotite, the probable reaction being as follows:—

$$\underset{\text{Olivine.}}{2\,Mg_2\,Si\,O_4} + 2H_2O + CO_2 = \underset{\text{Serpentine.}}{Mg_3\,H_4\,Si_2\,O_9} + \underset{\text{Magnesite.}}{Mg\,CO_3}$$

Under the action of hot carbonated waters containing silica, part of the iron component of the peridotite is carried off, and part converted into magnetite. In this case, the change from olivine to serpentine is effected in the following manner:—

$$\underset{\text{Olivine.}}{3\,Mg_2\,Si\,O_4} + 4H_2O + Si\,O_2 = \underset{\text{Serpentine.}}{2\,H_4\,Mg_3\,Si_2\,O_9}.$$

Peridotites are so prone to this alteration that it is seldom found in the fresh state. The heated carbonaceous solutions responsible for the conversion of the olivine and pyroxene components into serpentines accompanied the later granite phase of intrusion of the magma. Serpentinisation commences in minute fissures in the crystals of olivine, and continues until the whole is converted into a mass of fine, fibrous material.

Pyroxenes also are converted into serpentines under similar conditions. This is illustrated in the following equation:—

Diopside—

$$3\,Mg\,Ca\,Si_2\,O_6 + 3\,CO_2 + 2\,H_2O =$$

$$\underset{\text{Serpentine.}}{Mg_3\,H_4\,Si_2\,O_9} + \underset{\text{Calcite.}}{3\,Ca\,CO_3} + \underset{\text{Quartz.}}{4\,Si\,O_2}$$

The large masses of limonite occupying the surface areas, and the chalcedonic silica found here and there, are common derivations in the process of the serpentinisation of peridotites.

Certain peculiar serpentines in these districts are the alteration products of bronzite.

([7]) Benson, in his paper on "The Origin of Serpentine," discusses in detail the many theories advanced by well-known investigators, and as the result of his own observation arrives at the following conclusion:—

"The lines of inquiry followed support the view in regard to the large ultra-basic masses that the chrysotile or antigorite-serpentine, of which they are composed, is an alteration product of an originally intrusive peridotite, often more or less pyroxenic, and that in some cases at least the hydration was brought about by the agency of waters emanating from the same magma that produced the peridotite, though not generally until a considerable amount of further differentiation has taken place. The change, however, was completed by the end of the one orogenic period of vulcanicity." This accords with the views of the writer relative to the alteration of the peridotites and pyroxenties into serpentines as observed in Tasmania.

The formation of talc, commonly found in the serpentine belt, may originate in a similar way, but according to ([8])Clarke its commonest derivation seems to be by the alteration of amphiboles or pyroxenes. Thus:

Enstatite.		Talc.	Magnesite.
$4\ MgSiO_3 + H_2O - CO_2$	$=$	$Mg_3H_2Si_4O_{12}$	$+\ MgCO_3$

Economic Geology.

general features.

The study of the origin of osmiridium has excited the greatest interest among those engaged in its recovery, and has for many years attracted the attention of geological observers. The extraordinary fascination attaching to this study has arisen in large measure from its almost fabulous value from the capriciousness of its occurrence, and its comparative rarity. For many years after its discovery the origin of the mineral and the nature of its occurrence remained enveloped in mystery. Now it is generally known to be genetically related to the serpentinised rocks with which it is always associated. But the precise relationship of the mineral to the parent rock is not yet fully understood even by those directly engaged in the industry.

([7]) W. N. Benson, D.Sc.: "The Origin of Serpentine—A Historical and Comparative Study," Amer. Jour. of Sc. (Fourth Series), Art., XXXVI.

([8]) F. W. Clarke: "Data of Geochemistry," p. 604.

Osmiridium deposits were contained originally in certain igneous rocks of extremely femic character, such as dunites and peridotites, which subsequently were converted into serpentines. Deposits of this class were primary constituents of the igneous rocks, and were concentrated in their present form by processes of differentiation and cooling in molten magmas. The differentiation and consolidation of the magmas took place at considerable depths below the earth's surface, and the resultant rocks have been exposed by the denudation of the sedimentary cover

Some igneous deposits, like diamond in certain peridotites, occur as irregular disseminations; in other cases the ores are found in dyke form or in irregular masses such as those of magnetite and chromite. Again, particularly in extremely femic rocks, the deposits may occur in the form of short irregular streaky masses termed "schlieren," as in the osmiridium and platinum orebodies of Tasmania.

In order to submit a clear presentation of the principles involved in the formation of osmiridium deposits it is necessary to inquire into the nature of the parent magma, and to investigate the several processes through which it passes before arriving at its ultimate condition.

MAGMATIC SOLUTIONS.

([9]) To begin with, it is assumed that a magma previous to irruption is a mass of rock-forming matter in a state of fusion, and heavily charged with vapours and gases under enormous pressure. The different molten substances constituting the lava are solutions of definite silicate compounds in one another, which are, apparently, miscible in all proportions. It is considered that the magma is a solution because there is a lowering of the freezing-point, as indicated by the order of crystallisation, and because some of the last residues of crystallisation have the character of eutectic mixtures. In a molten magma the solutions of metallic salts are probably electrolytes, and in them the compounds are believed to be dissociated into their ions. This dissociation is proportionate to the degree of dilution, consequently the minor components are more completely dissociated than are the more essential minerals. It is found that the conductivity

([9]) The works "Data of Geochemistry" (F. W. Clarke) and "Mineral Deposits" (Waldemar Lindgren) have been consulted in the preparation of this summary.

increases with the viscosity, and with the silica component. It follows that the silicates in a magma are more or less dissociated into their ions according to the different degrees of their concentration. Probably the separation of certain oxides, silicates, &c., from cooling magmas may be ascribed to dissociation. In ordinary solutions two substances having an ion in common diminish the solubility of each other. For instance, olivine (Mg_2SiO_4) and enstatite ($MgSiO_3$) have magnesium ions in common, and under ordinary conditions would be the first to separate.

The successive crystallisation of minerals is dependent upon their solubility in the rest of the magma, and does not follow their temperature of fusion. An igneous rock, as in ordinary liquid and solid solutions, becomes fluid at temperatures below the average melting-point of its constituent minerals, and sometimes much lower. But no mineral can separate if the temperature for a given pressure is higher than the point of fusion of this mineral. Below this point crystallisation takes place whenever the point of saturation of the solution for this mineral is exceeded. Some of the components of the magma will form isomorphous mixtures with no eutectic depressions, but part of it will remain in eutectic proportions, which differ with the varying compositions of different rocks. In each case the substances that are in excess of the eutectic ratios are likely to crystallise first, and the groundmass will consist of the eutectic mixture.

DIFFERENTIATION IN IGNEOUS MAGMAS.

The problem of differentiation in igneous magmas is one which directly concerns us in the discussion of the formation of osmiridium deposits. In fact, it may be affirmed that, directly or indirectly, all primary ore-bodies have a close genetic connection therewith, although the association of strictly magmatic deposits is more apparent.

Petrologists have for long been at variance concerning the causes of differentiation, and also as to whether there were more than one fundamental magma from which the several differentiates have been derived. Some held the view that there were two fundamental magmas, the pyroxenic and the trachytic; others considered there were more than two, but among modern petrologists there is a concensus of opinion in favour of the idea that there

existed one original essentially homogenous magma only, and that the several varieties represent fractional differentiates from this parent stock. Bowen considers that the original stock magma had the constituency of normal basalt, and that crystallisation-differentiation was largely responsible for its separation into rocks of such extremely diverse character. He states that the order of arrival of magmas from the depths is to be explained on the basis of a single principal act of intrusion of basaltic magma with subsequent differentiation practically in place, and controlled in a general way by the size and rate of cooling of the individual bodies formed. The sequence of intrusion observed is the result of a sequence of consolidation of movements resulting in a certain amount of injection of one type into another, which may be wholly of a minor nature, and quite subordinate as compared with the main act of intrusion of basaltic magma.

The great plutonic formations which form the subject of this discussion, although showing a range from extremely femic to extremely salic, exhibit such a close relationship that they are regarded as having a common origin. In the case under consideration there were two phases of differentiaion. Firstly, there was the differentiation in place of the stock magma into a femic and a salic portion: and, secondly, after intrusion, these derivatives by further differentiation, were separated into their respective groups of rocks. Whatever the conditions were, and by whatever processes this differentiation was brought about, certain it is that the femic portion of the batholith, conrary to the usual order, was injected first into tht superincumbent strata, followed after a very short interval by the intrusion of the relatively large salic portion. It is noteworthy that the femic intrusive occurs almost always in proximity to the salic, and its surficial outlines suggest the form of a dyke. In some few instances the former is almost surrounded by the latter, in others apophyses of the latter intrude the former. It is particularly striking that where the salic magma intrudes the femic very little resorption has taken place, and the line of contact is so sharply marked as to suggest the consolidation of the latter prior to the intrusion of the former. It is now generally recognised that differentiation is brought about as the result of a number of processes of more or less importance, and that to no single agency in any specific case can this result be wholly attributed. According to their relative

importance these processes may be enumerated in the following order:—

1. Fractional crystallisation aided by gravitation.
2. The influence of dissolved vapours and gases.
3. Liquation.
4. Pressure.
5. Assimilation of foreign material.

In addition to these agencies there are several factors which are more or less operative, but none enters largely into the processes, and consequently none of them will be discussed here.

Bowen, a strong advocate of the crystallisation theory, states that the most promising processes for the production of differentiation are those involving crystallisation, and the relative movement of the crystals with respect to the liquid from which they separated. Of these the most importtant, during the period when the magma is still dominantly liquid on account of differences in density, is usually the sinking of crystals. During the period when the magma has largely crystallised the straining off or squeezing out of the residual fluid magma is the most important process.

The two processes involving relative movement of crystals and liquid—the sinking of crystals and the squeezing out of residual liquid—aid each other in a general way in the production of an arrangement of the various differentiates, such that the heaviest lies at the greatest depth, the lighter ones at lesser depth—in effect, a gravitative adjustment.

On the assumption that the stock magma was of basaltic nature the differentiation would result in a continuous gradation downward from salic to femic rocks. So far as the main portion of the batholithic mass is concerned, such conditions probably existed; but in the case under consideration, as already pointed out, there was an early femic differentiation and injection, for which another explanation must be sought. Since the outer parts of a body of magma are always cooler than the interior, there is a certain period during which crystallisation is taking place only near the border, the interior being still above the temperature of beginning of crystallisation. This offers a feasible explanation of the occurrence of the extremely femic rim of the batholith and the femic apophyses in the form of dykes, and accounts for the pre-

dominance of the salic over the femic rocks. In tnis process the femic differentiate separated from the magma, and, practically unaffected by gravitative forces, segregated towards the border. Under the enormous temperature and pressure, separation of the main mass by fractional crystallisation and sinking of crystals was not possible, and the other various aids to differentiation were comparatively inoperative. The dissolved vapours and gases, whose tendency it is to lower the melting points of minerals, would not, under these conditions, be effective as potential agents in the process. The partial disruption of the overlying strata along a line of weakness near the border of the intrusive mass resulted in the injection of the femic portion of the magma, which, in consequence of the release of pressure, became fusible and liquified. The further differentiation of the femic magma and the segregation of its constituent minerals then began. The isomorphous minerals olivine and enstatite, with their accompanying accessory elementary metals and metallic oxides, being the most insoluble and least fusible, separated out first. The others followed in the order of decreasing basicity.

Although the femic dykes show a fairly continuous gradation in composition towards the basic margin, and there is no sharp line of demarcation between the peridotites and pyroxenites, the outline of the gabbro is distinctly drawn. That the magma was gabbroid in character is evident by the occurrence at the lower border of narrow alternate bands of pyroxenite and saussurite indicating partial separation from the rapidly cooling mass. It seems, therefore, that this is an instance of ultimate differentiation in place, although the evidence is not conclusive. It is possible that the dyke fissure served for the passage of fresh supplies of material of varying composition, or even that the gabbro entered after the reopening of the dyke by fracture, but in no instance is the evidence available proof of this supposition.

Returning to the consideration of the residual magma after the separation and injection of the femic portion, the resultant release of pressure brought into operation the dissolved vapours and gases which became the chief agents in the completion of the processes of differentiation. That they were ineffective in the initial separation is evident by the extremely femic character of the rocks, and the occurrence of minerals in the elemental condition. However,

they were not entirely absent, as water occurs in pyroxenes, and certain oxides and sulphides are more soluble in femic magmas than in salic. In addition to the direct action of the vapours and gases they assist crystallisation by increasing the fusibility and by diminishing the viscosity of the magma. Their action takes greatest effect in the upper part of the lava reservoir, and according to their nature are they distributed in the molten mass. Thus water vapour, chlorine, fluorine, boron, &c., are prominent in the upper extremely salic portion, while sulphur, arsenic, &c., are more abundant in the femic. Returning from this digression the intrusion of the salic magma resulted in the formation of the great masses of granite, and the numerous porphyry dykes represent the final phase of the differentiation. The valuation of the several processes contributing to differentiation cannot be determined, but fractional crystallisation, the influence of dissolved vapours and liquation, are apparently the most effective, but to these agencies must be added the effect of pressure and the assimilation of extraneous material.

ORIGIN OF THE DEPOSITS.

The deposits dealt with in particular in this discussion may be divided for convenience of description into two classes, namely:—

1. Deposits formed by concentration in molten magmas.
2. Placers derived from the primary deposits by denudation and concentration in surface waters.

(1) Magmatic Deposits.

Under this heading are included concentrations of certain pyrogenic minerals which occur as primary accessory constituents of femic and extremely femic igneous rocks. Among the deposits included in this class are those of osmiridium, platinum, diamond and gold, certain oxides such as chromite, ilmenite and magnetite together, with a few silicates such as zircon and titanite and some metallic sulphides such as pyrrhotite, heazlewoodite, &c. It is particularly noticeable that the primary metallic minerals found in the extremely femic rocks occur, with one exception, in the elemental condition, while those commonly met with in the less femic formations are found in combination with other elements, such as oxygen, silicon,

sulphur, and arsenic. Thus osmiridium, platinum, diamond, and gold occur with chromite almost exclusively in the extremely femic rocks, bronzite and peridotite. Attention is at once drawn to the fact that of these chromite alone occurs in combination with another element. In this connection it may be mentioned that [10] Meunier, in studying the origin of chromite, obtained very interesting information bearing directly upon the point at issue. He obtained chromite by oxidising an alloy of iron and chromium, and suggested that such an alloy might be brought up from great depths and oxidised by vapours near the surface of the earth. Another noteworthy point in connection with these deposits is that the rocks bronzitite and peridotite, in which they are contained, consist solely of orthorhombic minerals such as olivine and enstatite. Marking the transition stage between the purely orthorhombic and the monoclinic groups of femic rocks certain rare sulphidic minerals such as laurite and iridium sulphide and amorphous iron sulphide are found. A little further removed are heazlewoodite, pyrrhotite, and chalcopyrite, pyrite, magnetite, &c., almost universal constituents of femic irruptive rocks. Again, nickel and cobalt minerals are pronounced basic elements, and are likewise almost without exception found genetically associated with rocks of the gabbro and pyroxenite types. Moreover, nickel minerals are found mechanically contained in pyrrhotite with chalcopyrite. The metals of the platinum group occur in periodic sequence with iron, nickel, and cobalt, which have similar physical and chemical properties, and have also a similar origin. The last three, being of lower atomic weights, are much more abundant, and their compounds are more soluble. There can be no doubt that the ores of these metals were primary constituents of the femic magma.

It has been pointed out that extremely femic or ultrabasic magmas are particularly lacking in acid-forming elements such as chlorine (one of the strongest solvents of the platinum metals and gold) and sulphur, and are also deficient in alkalis. It is known also that sulphides are much more soluble in femic than in salic magmas, and that their solution is much greater when the magmas are very hot than when they are at lower temperatures. The deficiency of the femic magmas in water vapour—which at extremely high temperatures is dissociated, and is a strong acid—and in acid-forming elements generally accounts in part for

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(10) Compt. Rend., Vol. 110, 1890, p. 424.

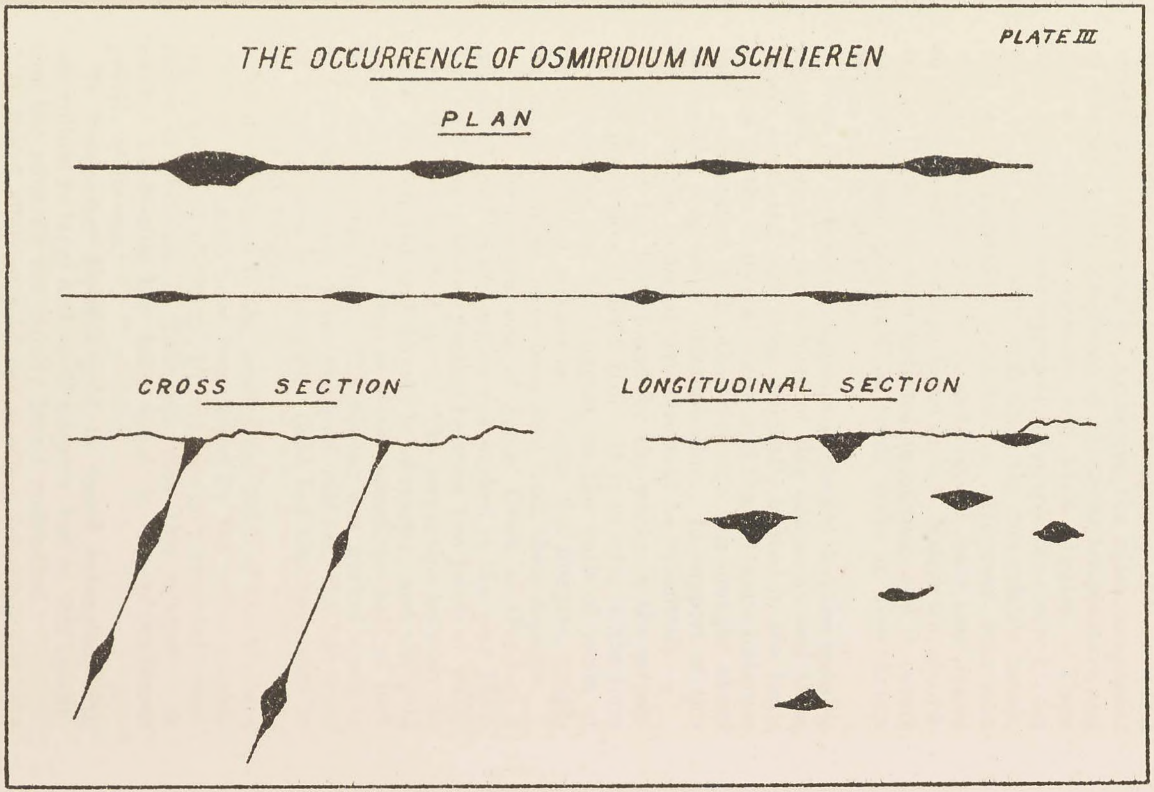
PLATE III
THE OCCURRENCE OF OSMIRIDIUM IN SCHLIEREN
PLAN
CROSS SECTION
LONGITUDINAL SECTION

the occurrence of the metallic minerals in the elemental condition. According to Arrhenius the silica component of magmas under conditions of enormous temperature and pressure occurs as hydrates and basic silicates. These basic silicates in their segregation towards the cooler border parts of the mass carry with them the non-volatile metals, and certain sulphides, arsenides, &c. However, even such volatile metals as tin, lead, and bismuth have been found as primary constituents in femic rocks. Native tin, according to Dana, has been detected in olivine, and it occurs associated with platinum in femic rocks in New South Wales and in the Urals.

From the foregoing it appears conclusive that the metallic minerals forming the subject of this discussion and those others associated with them originally existed in the femic magma in the elemental state, and that in some instances their combination with other elements was brought about during the progress of differentiation. In support of this contention the following evidence may be submitted:—

Free gold has been found by the writer in the serpentinised peridotites of Bald Hill. It is *in situ*, in the form of thin scales and flat nuggets, on the walls of joints or planes in foliated serpentine. Large flat nuggets, weighing up to 2 ounces, have been shed from these deposits.

([11])On the eastern side of Jones' Creek at Gundagi a deposit of gold in serpentine was worked in the year 1881. The gold was in the serpentine between two joints or walls, from 6 inches to a foot apart. The serpentine between the walls was foliated and fibrous in character, and the gold occurred in very fine films or plates, sometimes half an inch long, between the folia. The deposit was worked down to a depth of 90 feet, when the gold ran out, the last trace of it being seen in the wall. Gold has also been seen in serpentine at Bingara.

At many places in the osmiridium fields of the Western Division specimens have been found by the writer consisting of gold and platinum; in fact, the only recorded occurrences of platinum in Tasmania show this relation. A similar association has been noted in the platiniferous gravels of Borneo.

In Tasmanian deposits gold is found entangled with osmiridium in large and small nuggets, but in this association the minerals are usually found unattached.

In Brazil alloys of gold and rhodium (rhodite) and gold and palladium (porpezite) are known.

([11]) **Ed. F. Pittman : The Mineral Resources of New South Wales, p 63**

In nature osmium, iridium, rhodium, ruthenium, palladium, and platinum are found as a rule uncombined with other elements. These metals occur dissociated or in alloy one with the other in various proportions. Thus are known osmiridium, platiniridium, iridium, platinum, and palladium. Seldom is any entirely free from admixtures of other members of the group. Tasmanian osmiridium contains appreciable amounts of ruthenium and rhodium, a little palladium, platinum, iron, copper, and gold. Nearly all large specimens show intergrowth with olivine. Some Mt. Stewart specimens are made up of extremely fine-grained osmiridium disseminated through iridium and ruthenium sulphides.

Native copper has been detected in the platiniferous gravels of Aberfoil River, New South Wales. When copper is found in extremely femic rocks it is almost invariably in the elemental condition.

([12])Minute grains of native iron are not uncommon in certain eruptive rocks, especially the basalts. It has been found by G. H. Cook in the trap rocks of New Jersey; by G. W. Howes in the dolerite of Dry River, near Mt. Washington, New Hampshire; by F. Navarro in the basalt of Gerona, Spain; by F. F. Hornstein in basalt near Cassil, Germany. In the New Hampshire locality it occurs inclosed in grains of magnetite, suggesting a secondary derivation of the latter mineral from the metal. E. Hussak found particles of native iron in a platino-auriferous gravel in Brazil, and A. Daubrée and S. Meunier have described small masses of the metal from gold washings near Berezoosh in the Ural. These masses were notable because of the fact that they contained traces of platinum but no nickel. The most remarkable occurrence of native iron, however, is that at Ovifak, Greenland. Here large masses of native iron up to 20 tons in weight had been weathered out like boulders from the basalt, and in the rock itself lenticular and disc-like pieces of the metal were still embedded. The iron at first was thought to be meteoric, but its terrestrial nature was abundantly proved by the observations of Steenstrup, who found it disseminated throughout large bodies of basalt in place. There is no doubt that the iron in elemental condition was an original constituent of the rock. It contains from 2 to 3 per cent. of nickel and 3 per cent. of carbon.

Awaruite ($FeNi_2$) is disseminated in gravels and also as small grains in the serpentine and peridotite of Red Moun-

([12]) F. W. Clarke: "Data of Geochemistry."

tain, New Zealand, and josephinite ($FeNi_5$) has been found in serpentine detrital material in south-western Oregon and elsewhere.

Chromite, the chief ore of chromium, as already remarked, is found concentrated in the form of "schlieren," and as such is an important carrier of osmiridium. This mineral occurs also in irregular bunches, disseminations, and blebs. The presence of a little alumina in the femic magma results in the formation of picotite (chrome spinel), and it actually enters into the composition of rocks such as chromium-diopside.

In nature the diamond is invariably found in sub-silica rocks, and usually in those of extreme femic character. These rocks consist essentially of ferro-magnesian minerals such as olivine and certain pyroxenes. In meteorites the diamond has been found in olivine and also in iron. In the great diamond mines of South Africa the mineral occurs in volcanic pipes consisting almost wholly of peridotite. ([13])W. Luzi has shown that when the peridotite "blue ground" is fused at a temperature of about 1770 degrees centigrade the diamonds which it contains are perceptibly corroded. That is, the magma itself is proved to be a solvent of carbon which evidently was not derived from an outside source. ([14])Diamond has been identified by Professor T. W. Edgeworth David in a matrix of hornblende diabase at Inverell, New South Wales.

In the course of his analyses of hand specimens of chromite embedded in serpentinised peridotite from the Tulameen district R. A. A. Johnston obtained a residual product from fusion which proved on examination to be diamonds. ([15])C. Camsell remarks "that as far as our knowledge of the occurrence yet goes, the diamonds are associated with the chromite, and are not found in other parts of the rock-mass, so that their distribution depends upon that of the chromite. The matrix of the diamond is a peridotite of the variety dunite consisting essentially and in some cases wholly of olivine. Chromite enters in isolated places, but rarely occupies a more prominent position than that of an accessory constituent in the rock." Platinum and a smaller quantity of gold were also found to be associated with the chromite in these specimens.

The discovery of diamond in the peridotite rock of Bald Hill during the recent investigations of that area by the writer is the first recorded instance of its occurrence *in situ* in Tasmania. In this case the diamond is contained

([13]) F. W. Clarke: "Data of Geochemistry."
([14]) Rept. Brit. Assoc. Adv. Sci., 1906, p. 562.
([15]) C. Camsell: Memoir No 26, Canada Geo. Surv.

in olivine (dunite), and is likewise associated with chromite. Under the microscope it is seen that the diamond crystallised out before the chromite, while the matrix was yet uncrystallised.

The foregoing evidence shows that not only are the platinoid metals and gold almost universally associated, but that they frequently occur with chromite, and diamond almost invariably accompanies that mineral under identical conditions. Again, diamond is found in the platiniferous gravels of Borneo, Madagascar, British Columbia, Urals (Russia), and elsewhere. Moreover, iron and copper are not only found in the elemental state associated with the aforementioned, but with gold they enter into the alloy of the platinoid metals. It is found also that these elemental minerals invariably occur in association with extremely femic rocks.

Ore deposits formed by magmatic segregation are notoriously erratic. They not only show a varying degree of concentration, but vary greatly in their size, form, and distribution. In this respect the deposits under consideration are not exceptions to the general rule. They are, in fact, extraordinary examples of such bodies, and present many peculiar and interesting features. These ore-bodies occur in the form of "schlieren" irregularly distributed along structural planes or lines of differentiation induced in the rock magma during consolidation. These planes occur not actually at the point of contact with the intruded formations, but on the inside of the chilled portion of the igneous rock with which also they conform in strike and dip. The most prominent planes are arranged in groups parallel to one another and separated by completely serpentinised material containing particles of osmiridium very sparsely distributed throughout its mass. Some of these joints at surface are closed, others are filled with loosely-aggregated osmiridium-bearing ironstone and chromite, while a few are in places open cracks of considerable dimensions. The walls of these cracks show a development of steatitic material, which with the contained ironstone and chromite disintegrates more readily than the massive rock, and thereby accounts for the open cracks. The arrangement of the "schlieren" along planes parallel to the border of the dyke gives them a directional appearance, and encourages the mistaken idea of their occurrence in lode form.

I. *Placer Deposits.*

The largest part of the osmiridium production of Tasmania has been obtained from placer deposits, *i.e.*, detrital

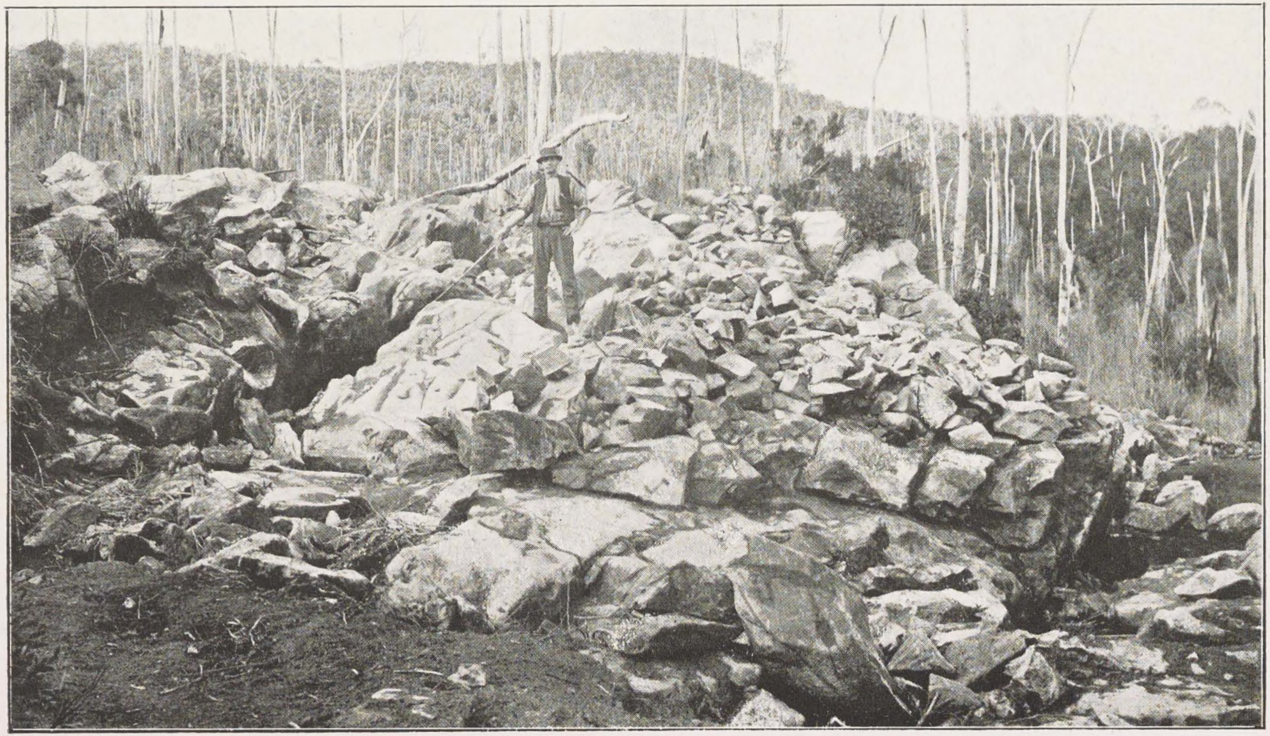

Photo. 5.—"SCHLIEREN" IN SERPENTINE, CAUDRY'S PROSPECT, ~~BALD HILL~~ Mt. Stewart. [A. M. Reid, Photo.

To face page 40.

and alluvial accumulations. Such concentrations are easily explored, and can be attacked by prospectors without a large initial expenditure, consequently these are the first resources of a district to be exploited.

These deposits are of three kinds:—

(*a*) Detrital accumulations;
(*b*) Surface alluvial concentrations;
(*c*) Sub-basaltic deposits.

(*a*) In many places where serpentines rich in osmiridium and gold are weathered at surface, especially in districts of considerable rainfall, the metals become concentrated in place by the removal of the disintegrated rock. The unequal distribution of the metals in the serpentine results in equally irregular concentrations in the detrital deposits. These deposits are neither deep nor extensive, but they are easily worked and very rich pay streaks are found in them.

(*b*) As the erosion of the decomposed serpentine goes on the detrital material is carried into depressions, and freshets result in its conveyance to gullies and ultimately to permanent streams. The tendency is for the coarser particles to remain near their source, while the finer are carried to creeks and from creeks to rivers, and the finest even to the sea. In steeply-inclined gullies very little alluvial material collects, but as the streams approach grade lateral erosion increases the width of the valleys and gravels and sands accumulate.

There is a strong tendency for osmiridium and gold to work downward through the gravels to the bedrock and become concentrated in joints and fractures therein. Normal stream erosion, assisted by eddies, cross-currents, and whirlpools, keeps the gravels and sands agitated, and reassortment of the materials of the gravels is thereby constantly taking place, and the heavy metals gradually find their way to the bottom. In flood time the greatly increased volume and flow of streams results in the removal of material held in repose under normal conditions, and so the finer-grained metals are carried farther and farther from their source. In this manner hundreds of feet of serpentine may be eroded, the disintegrated rock being carried away in streams, leaving behind the larger part of the heavy metallic components of the rock to enrich the gravels near the original deposits.

(*c*) Detrital and alluvial deposits may be buried under basaltic lava flows which covered the lower areas of the country as it then appeared. These lava flows may cover rich deposits, and one such is being worked in the Nineteen-mile Creek area at the present time.

Part II.

CHAPTER I.

DISTRIBUTION OF THE DEPOSITS.

The productive areas of Tasmania are confined almost exclusively to the Western districts. They extend from Heazlewood over 30 miles in a south-easterly direction to South Dundas. The country to the northward and southward of these extreme points has not been explored, and possibly extensions of the fields will be discovered in these directions as exploration goes on. What minerals lie hidden in these mountain and forest recesses remain for the future explorer to reveal.

The areas under discussion enclose a great serpentine belt about 30 miles long and 1 to 5 miles wide. It must not be inferred that osmiridium occurs at all points along this belt of country. Actually rich deposits are found only at certain isolated points where the ultra-basic differentiate consists wholly or partly of olivine and bronzite. Thus, in Heazlewood district the rich concentrations occur in the dunites, bronzitites, and peridotites on the north-west fall of Bald Hill, whereas the monoclinic pyroxenites and gabbros are comparatively barren, as shown by the almost total absence of the metals on the south-eastern fall. Again, at Mt. Stewart the osmiridium is confined to a small area of peridotite and bronzitite in the valley of Loughnan Creek, and the same conditions govern the distribution of the deposits in Wilson River district and elsewhere. From the northern extremity at Nineteen-mile Creek the belt extends unbroken to Castra Plain, where its southern continuation is interrupted by granite, which occupies the surface southward for several miles, ultimately giving place once more to serpentine. The severance of the northern from the southern fields by the granite intrusive has given rise to these two convenient geographical divisions. The Northern Division comprises the Long Plain, Heazlewood, Savage River, Badger Plain, Whyte River, and Mt. Stewart areas; and the Southern comprises the Wilson River, Harman River, Huskisson River, Renison Bell, and Dundas fields.

In addition to these there are isolated masses of osmiridium-bearing serpentines on the Arthur River fall about 6 miles beyond Heazlewood.

Southward of Macquarie Harbour is the Gordon, or Southern, Division embracing several isolated outcrops of serpentine. With one exception all of these are commercially unimportant.

The only locality in which osmiridium is known to occur in the Northern Division is the Salisbury field, near the mouth of Tamar River.

HEAZLEWOOD AND LONG PLAIN DISTRICTS.

The deserted hamlet of Heazlewood, from which the district receives its name, lies 13 miles by road from Waratah, which is connected by rail with the seaport of Burnie. About 25 years ago the Heazlewood was the centre of a flourishing mining area, in which gold, copper, lead, nickel, and tin mines were in operation. Its position on the road to the Long Plain and Corinna goldfields added to its prominence, but now only traces of the old settlements remain. Although spasmodic attempts are made from time to time to exploit the richest copper and lead ore-bodies, the chief interest in the district at present lies in the osmiridium and gold deposits. These deposits are found in the Bald Hill and Mt. Stewart areas, which are about 7 miles apart.

The road from Waratah rises imperceptibly up to a saddle in Magnet Range, thence into the valley of Whyte River, it follows the steep sidelong on a sharply descending grade. At 14 miles a tramway leads off in a southerly direction to Mt. Stewart, and at 16 miles the road skirts the southern fall of Bald Hill. Pack-tracks from the 15 and 19-mile pegs lead off in a northerly direction to different parts of the field. At the 19-mile the road enters Long Plain District, and continues to the 23-mile peg, from which the Savage River alluvial areas are easily accessible.

Previous Literature.

Although osmiridium had been authoritatively identified in the gravels of Savage River as far back as 1881, the earliest official reference to its occurrence in this locality is contained in a publication by A. Montgomery M.A., Government Geologist, issued by the Department of Mines in 1894. Since that time various official records have been made by geologists, the most important contributions being those by W. H. Twelvetrees. On the occasion of his last visit to these districts Mr. Twelvetrees investigated in par-

ticular the occurrences of osmiridium in the neighbourhood of Bald Hill, and his observations, together with a geological sketch map, were published in 1914 as Bulletin No. 17 of the Tasmanian Geological Survey.

The following publications refer to the district generally:—

Thureau, G: Pieman River Goldfield, 1881.

Thureau, G.: Report on Mt. Cleveland and Corinna Goldfields, 1884.

Thureau, G.: Report on the Ore-deposits in the County of Russell, 1888.

Montgomery, A.: Report on the Corinna Goldfield, 1894.

Smith, J. Harcourt: Report on the Mineral District between Corinna and Waratah, 1897.

Twelvetrees, W. H.: Report on the Mineral Fields between Waratah and Corinna, 1900.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Long Plains, 1903.

Twelvetrees, W. H.: The Bald Hill Osmiridium Field, 1914.

Reid, A. McIntosh: Iron Ore in Long Plain District, 1919.

HISTORICAL REVIEW.

So far as can be learned the earliest discovery of osmiridium in Tasmania was made in the valley of Wilson River about 45 years ago by Surveyor-General Sprent on one of his early expeditions through the Western districts. It was incorrectly identified by him as palladium (another member of the platinum group) which it closely resembles, and is so recorded on his exploratory chart. In the late seventies of last century during the boom period of the Corinna goldfield prospectors, operating in the neighbouring Whyte and Savage River areas, found an unknown tin-white, heavy, metallic mineral in association with gold in the alluvial deposits. This mineral was so abundant in certain localities that steps were taken to have it scientifically identified, and to ascertain whether or not it was of economic importance. It was soon recognised as osmiridium, for which there was no demand at that time, consequently the discovery created very little interest. The diggers considered this mineral an obnoxious impurity, because it was so difficult to separate from gold without the aid of quicksilver, and because a penalty of 7s. 6d. per

oz. was imposed by the Mint for its removal. All osmiridium recovered in the sluicing operations was discarded, and most of it thrown away. The digger in his search for gold traced this mineral up Savage River valley as far as Burnt Spur, the eastern boundary of the Corinna auriferous belt, beyond which payable gold had not been found, and exploration in that direction was for the time discontinued. The tracing of osmiridium further up Savage River to the point of confluence with Nineteen-mile Creek, and along the course of that creek to its source in the serpentine areas of the Bald Hills lays to the credit of a party of prospectors in the employ of Colonel Hughes, of Melbourne. Several miles of Savage River and Nineteen-mile Creek were leased in 1899 for gold-dredging, but on closer examination it was found impracticable to exploit the deposits by this means owing to the rock-bound condition of these streams, and the leases were ultimately abandoned. Up to this time all efforts to obtain a market for osmiridium failed, but several parcels filtered through to foreign consumers, who, appreciating the good quality and grainsize of the material, made further purchases, and so the industry was gradually launched. The price offered (25s.per oz. troy), although very small, gave encouragement to diggers to preserve the mineral. As the price advanced production increased, and soon osmiridium mining became firmly established. Operations, hitherto confined to Savage River, were extended by the veteran prospector, James McGinty, to Nineteen-mile Creek, where the richest concentrations have since been found. Consequent on the advance in price to 90s. per oz. in 1909 miners invaded this country, and also that in the neighbourhood of Wilson River, inaugurating an era of exploration and development which gradually brought about the highly satisfactory conditions obtaining to-day.

PHYSIOGRAPHY.

The rather complex history of the development of the physiographic features of this terrain will be discussed in detail in order to present an explanatory account of the occurrences of osmiridium and gold in alluvial material far removed from present drainage channels. For instance, all the osmiridium- and gold-bearing wash found on Badger Plain, Brown Plain, the plateau between Savage River and Nineteen-mile Creek, the hill summit near Warner Creek, on Bald Hill and Long Plain, and, in fact, on all the

elevated plateaux in these districts, originated in the development of the features of the country as they appeared in late Tertiary time. All these isolated areas are portions of an uplifted peneplain, which, at that time, stood at a much lower elevation. Across this peneplain a very broad, slow-moving stream, which had reached the base-level of erosion, meandered in a remarkably sinuous course westward towards the sea. Traces of this Tertiary stream are seen in the water-worn quartz, granite, and porphyry wash on the summit of the plateau near Warner Creek, at the source of Free-and-Easy, on Bald Hill, Long Plain, and Badger Plain. In what direction beyond Badger Plain the old river originally found access to the sea has not yet been ascertained. Overlying this old river wash, near the source of Free-and-Easy Creek, are thin seams of Tertiary coal, and in other places near-by are beds of basaltic clay. Basalt remnants are jotted here and there is every quarter of the old peneplain, indicating an extensive, though shallow, lava flow during this period.

With the subsequent uplift of the region the present cycle of erosion was introduced. The Whyte, Heazlewood, and Savage Rivers came into being, and have since entrenched themselves in deep ravines with terraced slopes, while their numerous tributaries have in a lesser degree accentuated the relief by shallow subsidiary channels. The resultant topography of the Heazlewood and Long Plain districts, which form one physiographic unit, is very hilly. The Heazlewood River joins the Whyte River south of Long Plain, and the latter flows into the Pieman River about a mile above Corinna settlement; and the Savage, also an affluent of the Pieman, meets the major stream 2 miles below. The larger streams have a general south-west trend; while the smaller ones are usually transverse, and the courses of some are governed by the geological formations. Thus are found deep-channels at the junctions of igneous and sedimentary formations. None of the streams has reached maturity, all are fast-flowing and actively engaged in reducing their beds towards base-level.

GENERAL GEOLOGY.

Sedimentary Rocks.

The oldest rocks, consisting of schistose sandstones and slates, occur in the western part of the region, especially in the Long Plain area. These strata are considerably sheared and contorted having been subjected to regional

metamorphism. These old slates and sandstones are not only interpenetrated with silica, but are so saturated with it as to be simply quartz schists. The argillaceous members have been converted into micaceous varieties.

The age of this series cannot be definitely determined, but on lithological and stratigraphic grounds they have been tentatively ascribed to the Pre-Cambrian, and probably are identical with similar strata in the Stanley River district.

Succeeding these are grey to black slates belonging evidently to the Dundas series, and therefore of Ordovician age. Intercalated with them are felspathic sandstones, and a deep dun-coloured, completely decomposed rock of obscure origin.

Strata belonging to the Silurian system crop out in the valley of the Whyte River at Godkin Mine, and also south of the 14-mile east of Mt. Jasper workings. They consist of limestones and sandstones replete with fossils typical of the system. The latter occur in all gradations, from the fine-grained, evenly sorted, white sandstones, through grits to white water-worn pebbles cemented into conglomerates. A characteristic feature of these strata is the peculiar cylindrical borings which traverse the sandstones generally at right-angles to the bedding-planes. Not all the layers, however, contain these borings and trails. The limestones are argillaceous, and of no great thickness, rarely exceeding 100 feet.

The following is a list of the more important species of fossils occurring in these strata:—

Trilobites—Genus *Hausmannia*, Sp. *Meridianus.*; genus *Cromus*, Sp. *Murchisoni.*

Annelida—Genus *cornulites*, Sp. *Tasmanicus.*

Brachiopoda—Genus *rhynchonella*, Sp. *decimplicata* and *capax.*

Pteropoda—Genus *Tentaculites*, Sp. ind.

Corallites—*Favosites Grandipora.*

The species present both a Lower and an Upper Silurian facies, with a preponderating tendency towards the latter.

On part of Long Plain and over nearly the whole of Brown Plain there is a superficial covering of water-worn gravel of considerable depth. In places the gravel, which is of Tertiary age, has been firmly cemented, forming a hard conglomerate resembling rocks of much greater geological age. Probably the cementation of these gravels has been induced by the baking effect of basaltic lava flows

which at that time were outspread on these formations. Between Brown Plain and Corinna the surface is covered with similar gravel and occasional patches of conglomerate, and like formations occur on Badger Plain on the west side of Savage River.

The alluvial gravels on Long Plain and on the plateau in Heazlewood district contain granite and porphyry pebbles and boulders and also fine-grained tinstone. Probably portion of that on Long Plain came from Meredith Range granites, but not necessarily so, for the gravels on the elevated country north of Nineteen-mile Creek were conveyed from the direction of Mt. Cleveland. It has been observed that the elevation of this old Tertiary peneplain shows a gradual declination westwards. At Upper Nineteen-mile Creek it is 1640 feet above sea-level, Long Plain is 1600, Brown Plain 1400, and near Lucy Spur these gravels are from 850 to 1000 feet above sea-level.

Igneous Rocks.

The oldest igneous rocks are the hornblendic, serpentinous, and talcose schists, which penetrate the Pre-Cambrian (?) schistose sandstones and slates. It is noteworthy that the trend of the structural planes of these igneous schists is a little east of north, whereas the strike of the zone is north-westerly. Although these schists have suffered greatly from the effects of regional metamorphism and decomposition, in places the rocks are only slightly altered and are fairly fresh. They were originally gabbro-amphibolites, and apparently represent the basic phase of the porphyroid intrusions so prominent in neighbouring districts. These have been doubtfully ascribed to the Ordovician.

The next younger are the femic and salic intrusives of Bald Hill and Meredith Range. These rocks were injected into the Ordovician and Silurian sediments at the close of the latter period, and have been generally referred to as of Devonian age. They are coarse-grained crystalline rocks of typical plutonic character, and as such were formed and consolidated at considerable depths below the surface. The femic are represented by the peridotites, pyroxenites, and gabbros of Bald Hill, and the salic by the granite of Meredith Range and the numerous porphyry dykes protruding here and there in these districts.

Remnants of a large basalt flow of late Tertiary age are scattered in every quarter of Long Plain and Heazlewood districts. Although widely distributed and parts of a

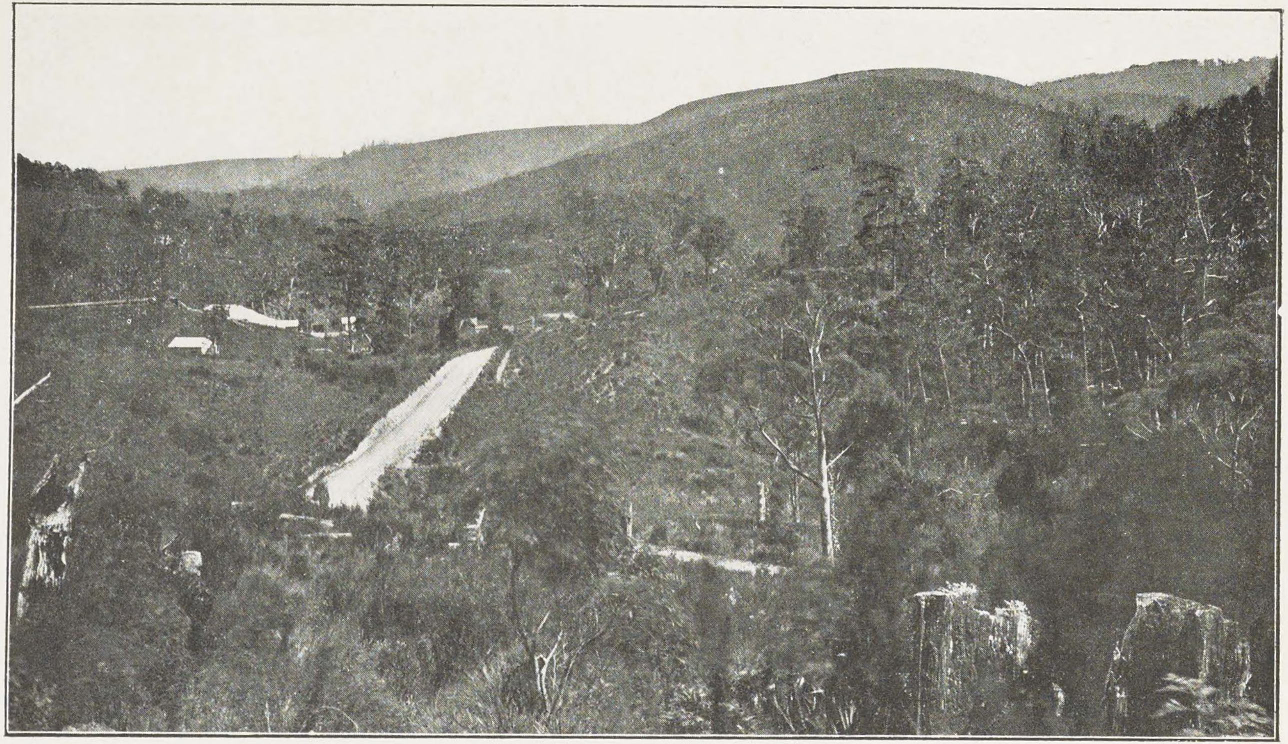

Photo. 6.—BALD HILL FROM CORINNA ROAD. [*A. M. Reid, Photo.*

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former continuous lava sheet, the total extent of these isolated masses now amounts to only 1000 acres. Apparently all of these occurrences represent lava sheets lying in the trough of an old Tertiary stream. These sheets overlie in places old river gravels containing the precious metals.

The basalt is the olivine-bearing variety so characteristic of the eruptions of basic lava of this age in Tasmania. It is a fine-grained, dark rock, and slightly vesicular in the upper layers. Amygdules filled with an undetermined zeolite are not uncommon near the top, but the lower part is compact and extremely dense. The thickness of these sheets is nowhere great, ranging from 100 to 200 feet in the larger masses.

Bald Hill Area.

Bald Hill is occupied by a mass of serpentinised femic rocks constituting one of a number of projections extending over an area about 30 miles from north to south and from 3 to 5 miles from east to west. Other exposures of serpentine have been reported several miles farther northward, but of these there is no official record with the exception of comparatively small femic dykes. These ultra-basic protrusions occur several miles beyond any exposure of granite rock. They consist of peridotites, pyroxenites, and saussurite-gabbro, and represent the result of the ultimate differentiation of the initial injection from the main magma Nineteen-mile Creek marks the line of contact on the north-west side between the igneous and sedimentary formations. The latter consist of soft grey and dark slates, and show little evidence of metamorphic action. The line of contact is emphasised by the luxuriant vegetation of the sedimentary rocks compared with the almost barren appearance of the serpentines. Land where serpentine occurs is unsuitable for agriculture or any other purpose because the soils resulting from the decomposition of this rock lack the alkalis so necessary for plant growth. Bald Hill, as its name implies, is almost completely devoid of vegetation, only button-rush and allied plants finding sustenance thereon.

This is, perhaps, the most important source of osmiridium in Tasmania. The area from which the osmiridium has been shed does not exceed 500 acres, yet all the metal found in the rivers and creeks hereabouts was derived from the solid rock in this area, having been liberated by the agencies causing decomposition and denudation. The

phenomenal rainfall of the western region is responsible for the present rather rapid erosion. The serpentine formations have been subjected to erosive agencies since early Tertiary time, and probably even so far back as the Mesozoic era. The deposits derived from them therefore represent the metallic content of an enormous amount of disintegrated rock. In this locality osmiridium of the best quality and grainsize is found. The distribution of osmiridium on Bald Hill area is confined almost exclusively to the north-western fall. However, the peridotites extend right up to the summit, and primary deposits may be looked for there; but the gabbros occupy the south-eastern fall, and, consequently, there is no likelihood of occurrences in the latter quarter.

Caudry's Prospect.—A reward claim, 6251-M, of 40 acres, was granted to W. Caudry for the discovery of osmiridium in serpentine on the western end of Bald Hill. The discovery was made by loaming up the hill on the north side of McGinty Creek to the source of the osmiridium in planes coursing in a north-westerly direction. It is stated that " colours " could not be obtained from the rock beyond this point. The workings are situated at the north-west corner of the section near the foot of the hill. They consist of an open trench, 150 feet long, 4 to 6 feet wide, and 10 to 15 feet deep, cut along the course of the plane. The soft, crushed, slickensided, white to yellowish-green serpentine of the so-called lode is derived from rocks rich in olivine and bronzite. Microscopical examination of this rock shows it to have been a typical peridotite consisting essentially of olivine and bronzite or enstatite. It is almost completely serpentinised, but the rock section shows here and there small particles of bronzite, chromite, and chrysotile, with secondary magnetite. The rock is very brittle and cleaves in all directions, although more freely parallel to the lines of orientation. In its normal condition it is a beautiful, dense, dark-green rock surrounded by concentric weathering rings from brown to light-grey, according to the degree of decomposition. Magnesite occurs on joint planes, opaline serpentine in reticulating veinlets and talc is commonly but irregularly distributed. These rocks a few chains to the eastward give place to others consisting essentially of orthorhombic pyroxenes such as enstatite and bronzite.

From the first excavations made on this line several ounces of osmiridium were obtained, principally from steatitic or talcose rock. Specimens of serpentine picked up

Photo. 7.—ROCK WORKINGS, CAUDRY'S PROSPECT, BALD HILL. [A. M. Reid, Photo.

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at random in this trench and containing no visible specks produced fine "colours" on crushing and panning. It is, nevertheless, extremely erratic in its distribution, for many specimens taken from the same place showed not a trace of osmiridium. The mineral is almost invariably coated with iron oxide and associated with clusters of crystals of chromite or magnetite. If it were not for its high specific gravity it would, on account of its rusty appearance, pass unnoticed. Chromite has been repeatedly observed here adhering to or interpenetrating the larger nuggets, indicating their contemporaneous formation. The owners of this property, more ambitious than their neighbours, erected a small five-head stamp-battery in order to crush and treat the material in bulk. The test was not satisfactory, for only a small quantity was put through. It is understood, however, that the owners contemplate an early resumption of operations, and they intend to prosecute the work on a much larger scale.

Since the writer's visit the detritus immediately below this formation and derived from its disintegration has been found to contain remarkably rich values, and the whole of this surface material is now being sluiced.

Pursell's Prospect.—On the summit of Bald Hill some sections were leased years ago for silver-lead ore. It was considered at that time that all gossanous cappings indicated the presence of galena underneath. The gossan outcrops here are composed of limonite intermixed with chalcedony and opaline silica, frequently quite cellular or cavernous. In some cases the walls of the cells are extremely delicate and appear to have a regularly formed, honeycomb structure. Intersecting these gossanous silica veins are numerous irregular bands of pyrite, pyrrhotite, and serpentinised materials. These formations consist of the fillings of structural planes developed in the serpentinised pyroxenites during cooling and consolidation. Their trend is generally north-east in conformity with the boundary of the intrusive rock, but subsidiary branch veins lead off from the main fracture planes in a north-westerly direction. These veins are not continuous, but are members of groups of veins arranged *en echelon* and extending for several miles. They vary in width from 1 to 3 feet, and have been exposed by numerous trenches at various points along their courses. The idea of their being repositories of lead ore has long since been abandoned, but subsequently they were considered by the miners to be the sources of the osmiridium shed into Nineteen-mile Creek. These so-called

lodes have proved disappointing, but osmiridium has actually been recovered from the serpentine wall-rock in several places, and probably rich pockets of the mineral may yet be found along this line. It must be borne in mind, however, that the gossanous silica was deposited in these planes subsequent to the osmiridium; therefore there is no relationship whatever between them. Both limonite and chalcedonic and opaline silicas were formed as by-products of pyroxenites and peridotites in the metamorphic processes involved in their alteration into serpentines.

About $1\frac{1}{4}$ mile north-eastward a trench, 20 feet long by 4 feet wide and 5 feet deep, has been cut across a 3-feet formation, similar to those described, bearing about 35 degrees east of north and dipping north-westerly. The outcrop is encased in soft bluish-green serpentinised rock, through which ramify veinlets of pyrrhotite, pyrite, and magnetite. These minerals are found also in the gossanous silica. Osmiridium, it is reported, occurs in the hanging-wall rock at this point; and several specimens of metal-bearing serpentine have been found in this locality. The walls of these so-called lodes are possible loci for osmiridium deposits. The distribution of the mineral along these planes is extremely erratic, as elsewhere, and only by very careful and diligent search can the small deposits be located. Between these two groups of workings an attempt has been made by the aid of a puddling plant to recover the liberated osmiridium from the clayey and peaty materials in which it is now contained. A block of ground, 200 feet long by 24 feet wide and 4 feet deep, has been puddled and sluiced in these workings. These operations would have been more successful if a larger supply of water had been available. There are, nevertheless, several very good claims in this locality, and doubtless as exploration goes on many other rich alluvial deposits will be located along the summit of the hill.

Nineteen-mile Creek Deposits.—This creek, one of the major affluents of Savage River, rises near the north-eastern end of Bald Hill, and flows on a south-westerly course for 5 miles before junctioning with the parent stream. Its channel follows the line of contact of the serpentines with the intruded slates, schists, and porphyroids. As Savage River is approached its valley becomes deeper and deeper very rapidly, until at the point of confluence it has attained a depth of 1100 feet below Bald Hill. Nearly all its numerous tributaries flow northward from Bald Hill, carrying with them, to augment the accumulations of their

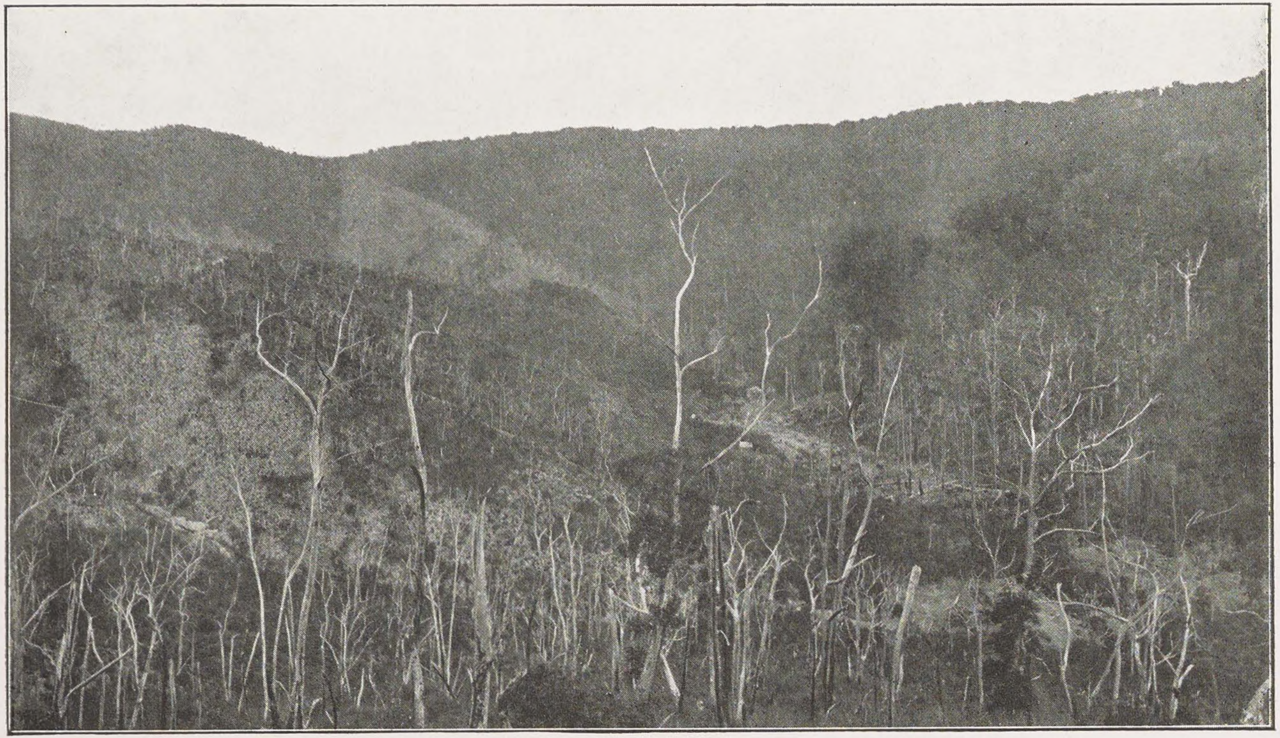

Photo. 8.—VALLEY OF NINETEEN-MILE CREEK, SHOWING JUNCTION OF SERPENTINE ON LEFT WITH SLATES AND SCHISTS ON RIGHT.

[A. M. Reid, Photo.

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parent, the materials of their own excavations. Practically the whole of the osmiridium and a large portion of the gold contained in Savage River valley were conveyed through this channel. This being the medium by which other large deposits received their quota of mineral wealth, the accumulations here are naturally very rich and provide a large proportion of the total output. Moreover, this stream in cutting its deep channel liberated from the serpentine rock on the south side the bulk of this material, and its tributaries contributed nearly the whole of the remainder from other original deposits in serpentine. A little has been derived from defunct streams by the reassortment of their gravels through present subsidiary drainage channels.

The " wash " varies in depth up to 15 feet and in width from 30 to 150 feet. It consists largely of the harder rocks such as gabbro, pyroxenite, basalt, indurated slates, and schists, with occasional pebbles of granite, porphyry, magnetite, limonite, and opaque quartz, the whole held together by comminuted serpentine. The osmiridium ranges in size from the finest grains up to nuggets weighing over 2 oz. Associated minerals are gold, gold-platinum, chromite, picotite, magnetite, pyrrhotite, and pyrite.

The mineral in this creek is gradually becoming scarcer and scarcer, and the ground remaining unworked is now comparatively small. In many places the bed of the stream has been worked over again and again, and if larger areas of sluiced ground were granted to diggers the deposits would be further treated by hydraulicing with a larger volume of water. At present, on these small claims the general way of winning the mineral is to pick or blast up the creek bottom and empty the stone into riffled sluice-boxes. The bottom has to be broken up to the depth of a foot or more in order to get the mineral which has settled into the crevices of the rock. The greatest care is taken in cleaning up the bottom rock, for on this the whole success of the venture depends.

In addition to the alluvial deposits in this valley a considerable area of detrital material high up on the hillside contains rich streaks. All that is necessary for their successful exploitation is to conduct water to them at a sufficient elevation. Master-joints in the serpentine have in certain places provided reservoirs for the collection of metal carried down by water. No doubt many rich pockets will yet be discovered in this locality.

Attention should be given to the open planes in the serpentinised peridotites. No serious attempt has been made

to develop the primary deposits in these joints because the erratic distribution of the mineral has discouraged operators. When the miners acquire a true conception of its mode of occurrence the exploitation of these deposits will not prove very difficult.

Warner Creek Workings.—This was the home of the largest nuggets of osmiridium found up to the present time. The stream is about one-half mile long, and flows north-westerly on a very tortuous course to Nineteen-mile Creek. It has carved its channel through Tertiary basalt deep into the underlying serpentinised peridotites, and near the point of confluence with the major stream it falls in steep cataracts through a gorge strewn with enormous boulders of basalt. On the surface of the massive serpentine a peculiar conglomerate, consisting of fragments of serpentine, peridotite, and chromite, held together by a magnesian-iron cement, has been developed, probably as the result of the physical and chemical effects of the basalt lava. Similar cemented material, now partly disintegrated, underlies the basalt eastward and is being worked for its content of osmiridium by Richards Bros. These miners have panelled a block of ground 50 feet x 40 feet by 6 feet deep at a depth of 20 to 30 feet below the surface. The top soil, 10 feet deep, consisting of clayey material derived from basalt, and the subsoil containing fragments of serpentine, are barren. According to the operators the payable ground is confined to a 2 to 3 feet band of soft, iron-stained agglomeration of broken serpentine resting on massive material of the same kind. In some places this broken rock contains very rich values in coarse-grained "metal," in others that of much finer grain predominates. Nearly all the specimens found here were coated with chromite or iron oxide, and most of them showed intergrowth with olivine.

Only one other attempt has been made to locate similar claims underneath the basalt cover. It is surprising that the failure of the second party has so discouraged others that the ground has remained unexplored to this day. There is no reason whatever why good claims do not exist under any part of the basalt area; in fact, the conditions there are particularly favourable.

The valley of Warner Creek has been worked from one end to the other, and a large quantity of osmiridium has been recovered in the process. Some of the small water-courses leading into the creek produced very rich material. In all cases the bulk of these accumulations has been shed from structural planes. The material in the bed of the


PLATE IV
Peridotite
Bronzitite
Pyroxenite
Gabbro
Schists, Quartzites, and Slates
NINETEEN-MILE CREEK
Warner Creek
Jones Creek
BALD HILL
Burgess Creek
HEAZLEWOOD RIVER
N

creek consists largely of water-worn pebbles of granite and quartz, evidently carried down from the bed of the defunct Tertiary stream on the plateau. This wash rests on decomposed serpentines containing rich osmiridium values. A considerable portion of the " metal " of this material is evidently concentrated in place, because further deposits are shed as the disintegration of the rock goes on. After the lapse of a few months the softened surficial material is chipped up again and sluiced as before. Gold in appreciable quantities is recovered with the osmiridium, and gold with platinum attached in small scales is not infrequently met with.

It is worthy of mention that the very large nuggets were evidently shed from planes trending in a north-south direction across a small watercourse worked by G. Fenton. Very good results were obtained in sluicing the detritus up to the planes, but only the smallest traces were obtained beyond them, indicating their derivation from this source.

Free-and-Easy Workings.—The source of this creek is on the plateau between Savage River and Nineteen-mile Creek. It is a very small stream draining the flat, almost swampy, bed of an old (Tertiary) river channel, now covered with thick scrub and stunted trees. The reassortment of the gravels of this old stream and the concentration of the contained minerals by the waters of Free-and-Easy Creek resulted in the formation of the richer deposits at present in process of exploitation. In the lower part of the creek the wash, if so it can be called, consists dominantly of slate and schist fragments with abundant basalt, quartz, and serpentinised basic rock, and occasional pebbles of gabbro and porphyry. As the summit of the plateau is approached the alluvial ground spreads out and the wash completely changes in character. Here it consists of fresh gabbro, white felspar porphyry, basalt, hornstone, jasper, and igneous schistose rock. In some places this wash is covered with a peculiar conglomerate made up of schist, gabbro, quartz-felspar porphyry, quartz, and Tertiary coal, cemented by basaltic material; in others a soft, grey, basaltic pug, which has not yet been penetrated, occupies the surface. The bedrock near the southern end is indurated slate, succeeded in a northerly direction by hornblendic schists and by dark-green serpentines, the last probably derived from the decomposition in place of basic dykes. Prospects of the wash near the lower end show " colours " of osmiridium and gold with picotite and chromite in abundance. Higher up stream the metallic

components increase in quantity and size of grain. The precious minerals here are accompanied by ruby-coloured zircons, sapphires, tinstone, picotite, and chromite. Some specimens of gold show rounded outlines, others are sharp and jagged. This portion of the creek wash contains osmiridium in payable amount. Near the head waters of the creek the metal values decrease, and the wash becomes shallower and shallower until the cost of production exceeds the value of the material recovered. It is impossible at this stage of development to delimit the boundaries of payable osmiridium-bearing ground on the plateau. Other rich concentrations may be revealed as exploration goes on, for traces of these metals are found over the whole area. The thick scrub greatly interferes with exploration, and the scarcity of water for sluicing purposes is a serious drawback in the development of this portion of the field.

Before concluding these remarks it may be mentioned that the materials of the old river gravels on the plateau have been derived from formations lying to the eastward. It is known that quartz-felspar porphyry dykes outcrop on Mt. Cleveland, and here also hornstone has been developed by the metamorphic effect of these acidic dyke rocks on the slates. The jasper and quartz, and perhaps even the gabbro pebbles, were brought from the same locality. It is possible also that part of the metallic minerals came from unknown basic formations in that direction, as the flow of the old stream was south-westward.

Jones Creek Workings.—A very narrow divide separates the source of this from that of Nineteen-mile Creek. This stream flows north-easterly for 3 miles to Heazlewood River, while Nineteen-mile Creek takes the opposite course to Savage River. Jones Creek follows closely the north-eastern boundary of the intrusive serpentinised rocks and the northern fringe of basalt. The workings are confined to the bottom of the valley, and extend from one end of it to the other. It is found that the richest concentrations are confined to certain sections of the creek, and from observations it appears that the bulk of the osmiridium and gold has been shed from the upper reaches along the basalt fringe. This occurrence is almost exactly identical with that of Warner Creek. The osmiridium obtained here is supposed to be of poorer quality than the Nineteen-mile mineral, but in appearance it is difficult to distinguish one from the other. Gold is abundant, predominating over osmiridium in places, and gold-platinum has been reported. In the lower workings 6 feet of detrital material overlies

2 feet of metal-bearing wash resting on decomposed serpentine originally derived from pyroxenite. The greater part of the metals is found embedded in the basal rock. There is only a small area in this locality remaining unworked. Higher up the stream, near its source, the superficial material has been sluiced, but no attempt has been made to remove the serpentine conglomerate in the bottom in order to ascertain what values lie underneath. In the loam and detritus on both sides of the valley " colours " are found, but not in sufficient quantities to prove payable. The sub-basaltic deposits should be worthy of more attention.

Burgess Creek Deposits.—This creek has its source in a deep embayment on the south-east side of the long basalt ridge which separates these from Jones Creek waters. This button-rush covered basin is about 40 acres in extent, and is almost completely surrounded by hills. On the south-east side the creek finds an outlet and junctions with Heazlewood River 2 miles farther on. The flat surface is occupied by 6 inches to 2 feet of peaty soil, underneath which is a few inches of serpentine rubble resting on fairly hard serpentinised pyroxenite. In places massive serpentine outcrops, the top soil having been completely removed by freshets in the creek. Both the osmiridium and gold found here have irregular outlines, and nuggets up to 5 dwt. have been recovered. A considerable portion of these metals, however, occurs in very fine-grained particles. This area has been neglected for richer deposits in the neighbourhood, but further attention will be directed here as those are depleted. Outside the basin very little osmiridium has been found on the southern side of the basalt hill, and in the lower stretches the creek is comparatively barren.

Racecourse Plain.—This plain is covered with Tertiary alluvial materials resting on gabbro. Only very small traces of osmiridium and gold have been found in the many holes sunk through the gravels at widely-separated points. The comparative barrenness of these gravels is due to the general lack of osmiridium in gabbro rocks.

Heazlewood River Deposits.—Along the banks of this river are numerous remnants of terraces marking alternate periods of deposition and degradation. These remnants of alluvial material extend on one side or the other in some places for many chains. Nowhere, however, are there deposits of great value in this valley. All of the osmiridium, and practically all of the gold, found here has been derived from the north-west border of the peridotite

formations, having been conveyed to its present position through the channels of Burgess and Jones Creeks. None of the streams flowing into Heazlewood River from the east slope of Bald Hill contains osmiridium in more than minute quantities, consequently this area as a contributing source of supply is excluded.

The "wash" varies from a few inches up to 10 feet in depth, and consists largely of quartzose rocks with gabbro, granite, and pyroxenite. The osmiridium and gold are of fine grain size and are sparsely distributed through the material from top to bottom. The richest concentrations, naturally, are found on and near bedrock.

Several attempts have been made to profitably exploit these deposits, but all have ended in failure.

Fitzgerald's Prospect.—Originally held by G. Fenton and later incorporated in the Bald Hills Osmiridium Mines, N.L., this property is now leased by James Fitzgerald. From the workings in the valley of Fenton Creek over 100 ounces of osmiridium of exceptional grade and quality have been produced. All of the metal recovered was of fairly coarse grainsize, some of it in nuggets up to one-half ounce in weight. These nuggets consisted of clustered crystals welded together without aid of foreign material. Neither the osmiridium nor the accompanying gold show marks of attrition, and evidently their source is in the bronzite and peridotite rocks dissected by the creek and its tributary streams.

On the hill summit at the head of Fenton Creek there is an outcrop of limonite and cellular silica in every way similar to those occurring on Bald Hill. Opaline and chalcedonic silica occur with the cellular form. The walls of the cellular variety are extremely delicate and fragile. It may be definitely stated here that the formation of these limonite-silica deposits was subsequent to the deposition of the osmiridium; therefore they have no economic significance at all. Serpentine is an alteration product and not a primary rock. It is generally recognised now that large masses of serpentine are formed from peridotite and pyroxenite rocks by the chemical action of hot carbonic acid solutions containing silica. In this reaction part of the iron component of the peridotite or pyroxenite is carried off and redeposited with silica in fissures, and part of it is converted into magnetite. This accounts for the deposition of chalcedonic silica and limonite (hydrated oxide of iron) in the form of lodes.

Photo. 9.—CAUDRY'S PROSPECT, MT. STEWART. [*A. M. Reid, Photo.*

To face page 59.

It is stated that prospects of osmiridium have been obtained from this material, but such reports have not been confirmed by subsequent tests. Samples examined by the writer showed no trace of osmiridium. This formation has been tested at depth by means of a crosscut put in from the head of Fenton Creek at right angles to the strike on a bearing of 109 degrees. Several bands of chalcedonic silica and limonite were passed through, and at 150 feet from the entrance the main body was intersected. This body was further explored by driving 40 feet along its course in a northerly direction. The siliceous material occurs here in a very irregular manner intermixed with bronzitic serpentine, and apparently is quite barren.

At the entrance to the tunnel the serpentine is a greyish-green to dark-green and almost black rock, showing dark blotches set in a ground-mass of lighter shade. The light serpentine is decomposed olivine and the dark an alteration product of pyroxene. In the tunnel the peridotite gives place gradually to pyroxenite, and typical bronzitic serpentines prevail. It is considered that the bulk of the metal recovered from the creek detritus has been liberated by denudation from the olivine-rich rocks west of the tunnel. Attention should be paid to this rock on both sides of the stream down to the point of confluence with Nineteen-mile Creek.

Mt. Stewart Area.

Osmiridium has been known here for many years. The district was visited in 1914 by Burge and Smyth, who recovered 17 dwt. of the siserskite variety from wash near the silver-lead mine. In 1917 Stanton and Loughnan were granted a reward claim of 10 acres for their discovery of osmiridium in Loughnan Creek. The mineral was found to occur here in such attractive quantities that a " rush " set in and soon the whole area was taken up.

This field lies about 5 miles by tramway south of the 14-mile peg of the Waratah-Corinna-road. The so-called mountain, from which it takes its name, is only 1645 feet above sea-level and 750 feet above Whyte River. From Whyte River the serpentine belt extends southward 4½ miles, and from east to west it is from 1 to 1½ mile across. On the west, south, and east sides it is walled in by granite, and narrow dykes of this rock penetrate and actually intersect the serpentine near the centre of the mass. In Castra River, close by the tramway bridge, diopside crops out, succeeded a little farther south on the hill by gabbro-

amphibolites, which in their turn give place to pyroxenite and peridotite formations. The surface of nearly the whole area is covered with limonitic ironstone set free during the serpentinisation of the basic rocks. On the silver-lead mine sections granite porphyries near the serpentine contact have been so completely transformed into schists that they are almost unrecognisable as igneous rocks. Other peculiar metamorphic effects illustrated here are the development of opaline serpentines and the formation of large veins of crystallised talc of remarkable purity. At the southern end of the field on Castra Plain the serpentines are extremely brittle and have a peculiar baked appearance suggesting that the granites were intruded after the consolidation of the basic rocks. Apparently there has been little or no resorption of the serpentines by the later salic magma, for the point of contact of these dissimilar rocks is very sharply marked.

The rich osmiridium deposits in this field are confined to the narrow valley of Loughnan Creek, which rises in a serpentine spur leading off eastward from Meredith Range. This creek flows due north for 3 miles before emptying into the Castra about ¼-mile above its confluence with Whyte River. Its channel is wholly contained in serpentine, but very close to the western border thereof. On its course towards the Castra the creek has cut obliquely across numerous osmiridium-bearing structural planes from which large quantities of the mineral have been liberated and concentrated in the gravels. The watershed of the creek is a broad basin lying between Mt. Stewart and Meredith Range. At the upper end of this basin is Caudry and Ramsay's 10-acre lease, which has produced more osmiridium than any other section of equal area in Tasmania. Directly below this in the flat country are other rich claims, and farther down, where the stream flows swiftly through a narrow gorge, are shallow deposits now nearly all worked out.

Section 8121-M, 10 acres; lessee, W. Caudry.—This property, situate at the head of Loughnan Creek, is owned by five prospectors, who located very rich nuggety "metal" there in June, 1918. Since that time the fortunate discoverers have recovered several thousand pounds worth of osmiridium from talcose ironstone material shed from three sharply-defined structural planes in massive serpentinised peridotite and bronzitite. Generally, complete serpentinisation of the rock has been effected, but in places it shows only partial alteration. Under the microscope the ser-

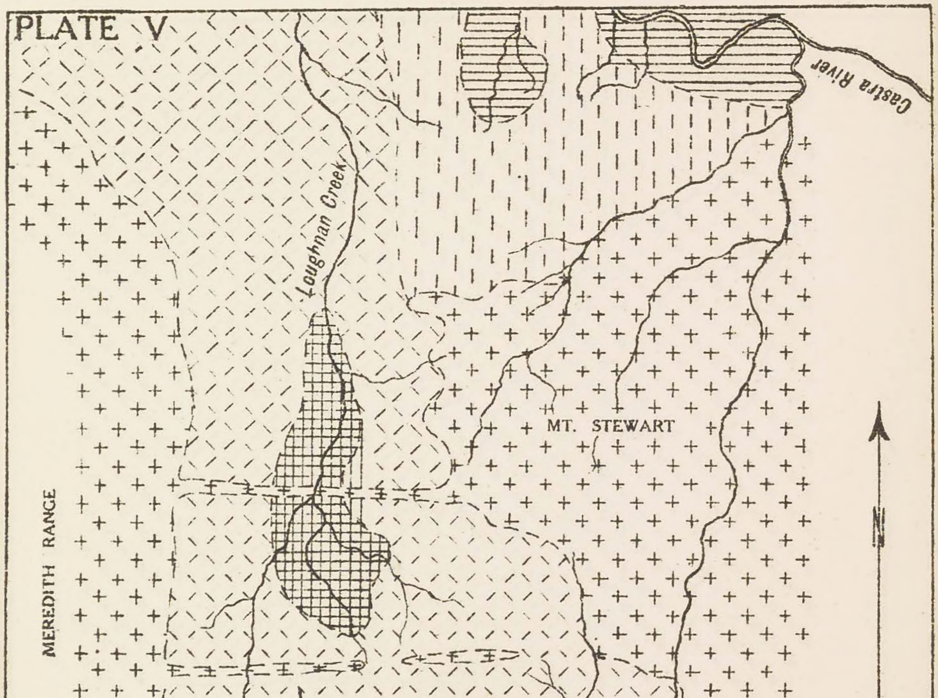


PLATE V
Loughnan Creek
Castra River
MT. STEWART
MEREDITH RANGE
N
Granite
Peridotite
Pyroxenite
Gabbro
Slates

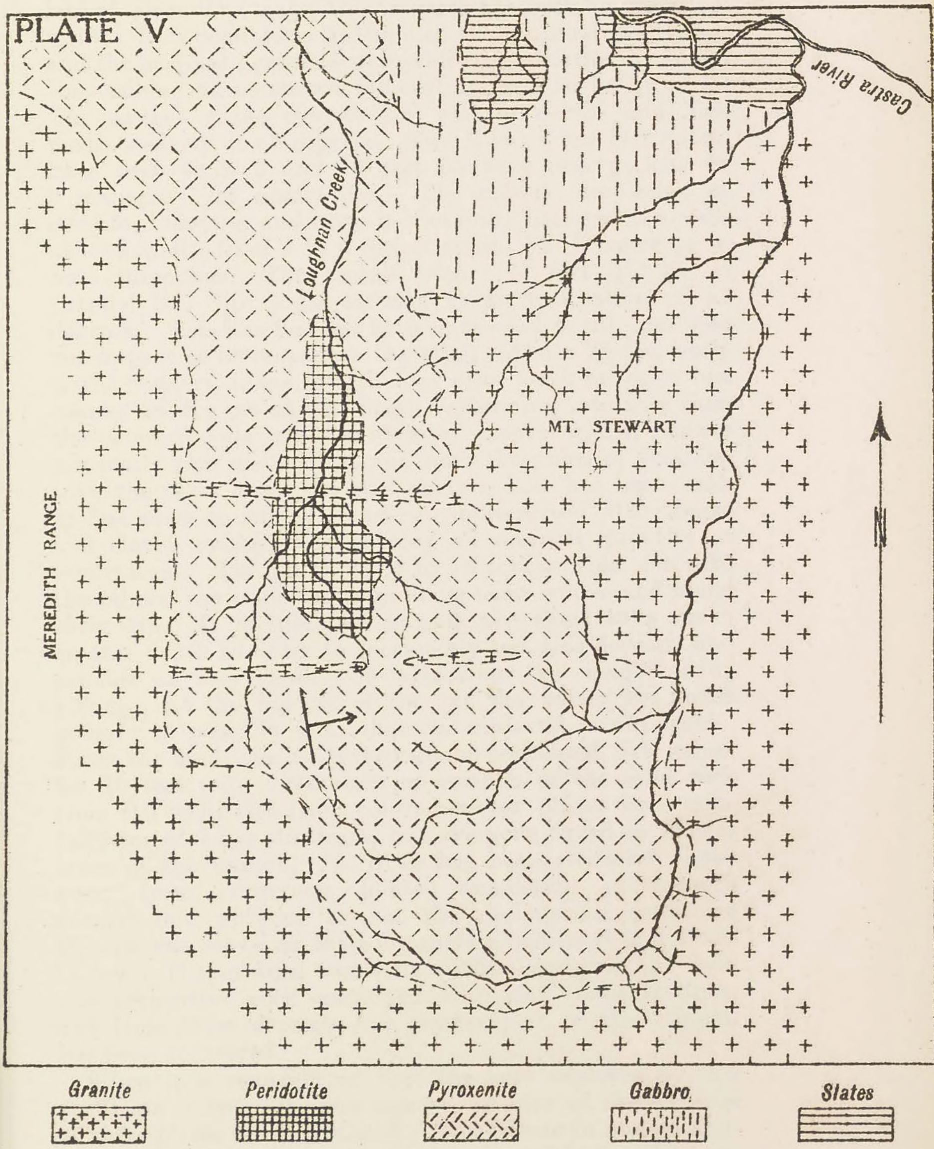


PLATE V
Loughnan Creek
Gastra River
MT. STEWART
MEREDITH RANGE
N
Granite
Peridotite
Pyroxenite
Gabbro
Slates

pentine is seen studded with chromite, and minute veinlets of secondary magnetite traverse the rock in all directions. It is possible to distinguish the outlines of olivines, and the original pyroxene was evidently enstatite, although the visible undecomposed mineral appears to be bronzite. The eastern plane courses 20° east of north, and dips north-westerly at 65 degrees. Two holes, a few feet apart, have been sunk 6 and 10 feet on very rich pockets or "schlieren" of osmiridium. The matrix, consisting of steatite, limonite, and clay, is contained between two well-defined walls, from 3 to 8 inches apart, which converge in both directions. The middle plane, 20 feet distant, is parallel but dips south-easterly at an inclination of 85 degrees. This one has not been developed at all, and does not appear so attractive as the other. About 25 feet away is the western plane, which also dips south-easterly, but courses 35 degrees east of north. Running into this from the western side are two lateral planes which contain unusually rich material at and near the point of junction with the main one. At this point a hole has been sunk 25 feet deep on rubbly ironstone, interspersed with talcose and clayey materials containing an unusual quantity of osmiridium. The plane is 12 to 18 inches wide, but like the others, the walls converge along their course and along their dip. It is intended to sink the shaft to a much greater depth in order to thoroughly test this deposit, and provide an easy means of attacking the neighbouring planes. At the bottom of the pit the values are much poorer; so poor, in fact, that the material is unpayable. From the shaft the transverse plane contained rich values for 10 feet only. Numbers of samples of the solid rock from the walls and from points between planes were carefully tested for osmiridium, but everyone failed to show a trace of the mineral. A little has been recovered, however, from transverse joints, connecting north-south planes, but whether or not the osmiridium contained therein was conveyed there by surface waters it is difficult to say. The surficial ironstone rubble overlying the massive serpentine rock contained very rich concentrations, and from these deposits the greater part of the mineral has been recovered.

When it is remembered that the area explored by this syndicate is only 30 yards square, an idea of the richness of these places can be realised. The failure in understanding the habit of these deposits is responsible for the tem-

porary stoppage of work. The operators should continue developments on the planes, both in a lineal and a vertical direction, in order to locate other "schlieren." It will be found that the walls will converge and diverge along their course and along their dip. This should not be considered a discouraging feature, as such deposits invariably occur in this manner.

Generally, the osmiridium occurring here is coarse, and even nuggety, the largest weighing 1 oz. 9 dwt., and several others have been recovered 14 dwt. and upward.

The absence of osmiridium in the wall-rock and in the serpentinised bronzitite between the planes is a peculiar feature of these deposits, and of such import that this fact should not be overlooked in the design of future operations. It is reported that the mineral has actually been detected in the rock in this locality, but the fact remains that the rich concentrations are confined to the planes.

The quarrying method is the most suitable for the exploitation of this class of deposits. By this means the barren rock can be easily discarded, the rich material recovered, and the vagaries of the deposits can be closely followed.

Acknowledging the notorious capriciousness of osmiridium deposits, there are here decided possibilities of their successful exploitation by quarrying methods, providing that the current market rate prevails.

Humphries Creek.—Very shallow deposits have been worked for 20 chains up the bed of this small affluent of Loughnan Creek. The rock, a soft peridotite in which olivine predominates, decomposes into a light yellowish-green serpentine. By further metamorphosis, the serpentine has been converted into talc and lepidomelane, the former of exceptional purity and beauty. Near the mouth the rock consists wholly of bronzite exhibiting unequal stages of serpentinisation, and presenting a peculiar mottled appearance. Coursing across the creek are several sharply-defined structural planes bearing 340°, and dipping north-eatserly at an inclination of 85°. It is quite evident that the bulk of the osmiridium obtained here has been shed from these planes.

On the south-west branch of this creek two very distinct and continuous planes, 6 feet apart, with several others at greater intervals, occur in peridotite rock. These have not been prospected.

Photo. 10.—LOUGHNAN CREEK WORKINGS, MT. STEWART. [A. M. Reid, Photo.

To face page 62.

Tunbridge and Kelly's Prospect.—This claim lies north and adjoining Section 8121-M, and, like the latter, is occupied by bronzitite and peridotite, rocks, now almost completely altered into serpentines. These rocks are traversed by planes coarsing in a meridional direction, and by numerous lateral joints connecting them. The surficial alluvium and detritus yielded very rich material, and from the decomposed filling of the cracks very good nuggety metal is now obtained. There is no doubt that the osmiridium occurs here *in situ*. The bronzitite and peridotite rocks in this area and elsewhere are the homes of these metals, and wherever they occur osmiridium may be found.

The present methods of exploitation are primitive in the extreme. As the metals are contained in the ferruginous steatite fillings of joints and planes, the object is to effect a separation of the massive boulders of serpentine and their removal from the workings. For this purpose blasting is resorted to, and the broken rocks are removed by hand or wheelbarrow. The metal-bearing material is then carefully gathered and sluiced.

The small amount of ground worked on this claim has yielded about 60 oz. of osmiridium of very good grade. It occurs here usually in nuggety or shotty form, and is almost invariably coated with limonite. The largest nugget found here weighed 1 oz. 12 dwt., and many more upwards of 1 oz. have been recovered. Occasionally nuggets of the peculiar mineral containing iridium, ruthenium, and iron sulphides with mechanically involved osmiridium are found in the joints and planes in the serpentine on this property. Other specimens are found in Humphries' Creek and in places lower down-stream in Loughnan Creek.

Clementson's Claim.—The formation and conditions generally are essentially similar to those obtaining within Tunbridge's area. Nearly the whole of the alluvium and detritus have been treated, and attention must soon be given to the underlying serpentine rock.

In the alluvial material the operator frequently unearths small nuggets of iridium-ruthenium sulphides, containing a large amount of finely-divided grains of osmiridium. Freshly broken the specimens possess a bluish-black, semi-metallic surface, in which minute dull-coloured grains of osmiridium can be perceived. Nuggets of this material are commonly found also in Humphries Creek, Tunbridge's claim, and in Caudry and Ramsay's. A high iron content is characteristic of the metal obtained in this locality.

Stanton and Loughnan's Reward Claim.—This is situated about 30 chains north of Caudry's section, in the valley of Loughnan Creek, which passes through the centre of the property. From the detrital material on this section over 100 oz. of osmiridium have been produced. Very little unworked ground of this nature remains, but what little there is continues to produce the metals in highly payable quantities. Osmiridium is accompanied here by gold, tinstone, native bismuth, and chromite. The tinstone and bismuth, as indicated by the large proportion of granite pebbles and boulders in the wash, have been conveyed to this position from Meredith Range.

Some of the osmiridium nuggets found here are smooth and compact; others are made up of crystal aggregates, and are coated with iron oxide. Fine flaky metal is also found with that of shotty grade.

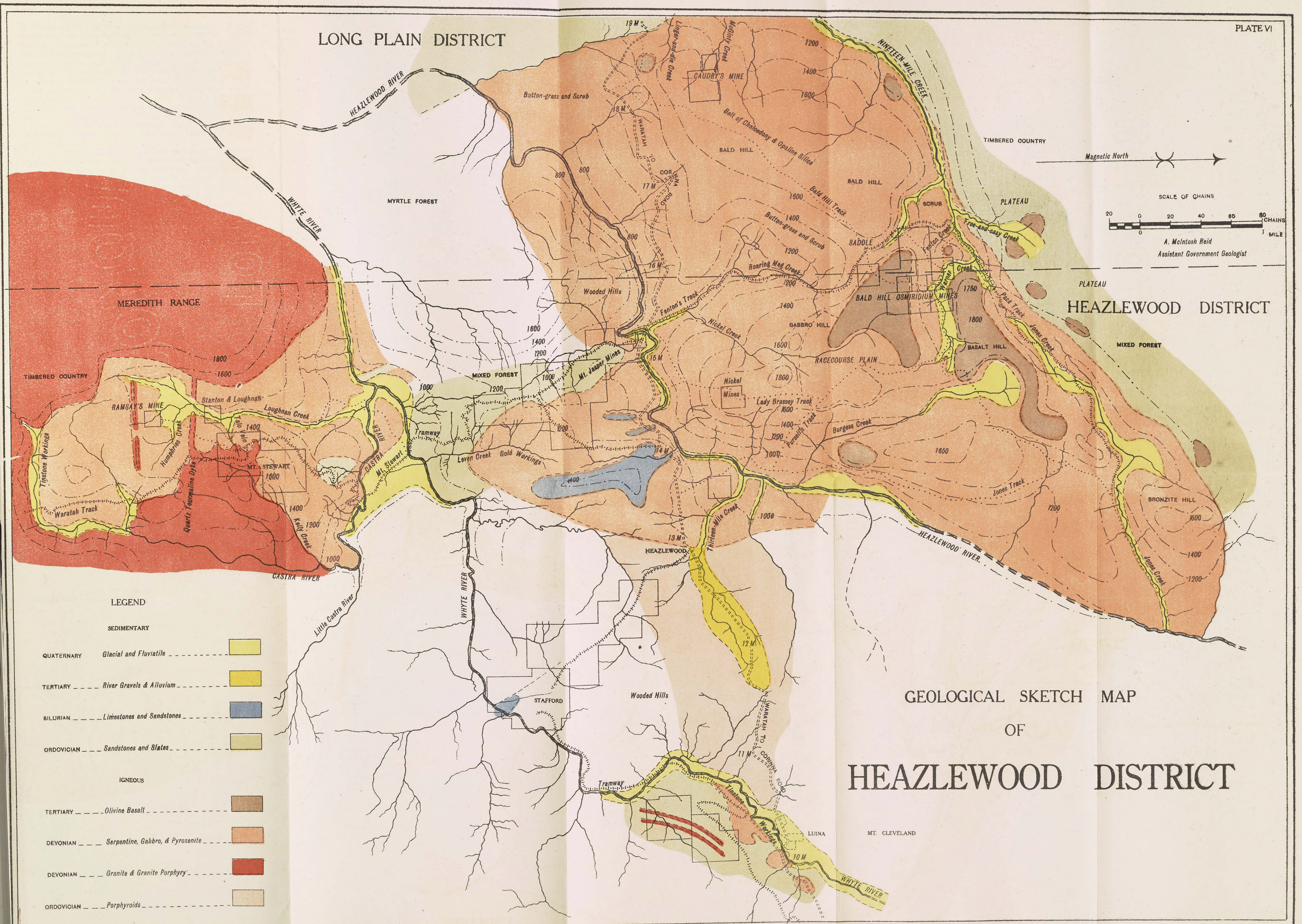
No attempt has been made to locate primary deposits in the rock on this section, the condition for which are decidedly favourable.

Castra River.—The richest deposits of osmiridium in this valley have been found at the point of confluence with Loughnan Creek. Whyte River flows into the Castra about 20 chains further down-stream, and the valley between that point and Loughnan Creek is broad and covered with alluvial gravels containing tinstone, monazite, and gold, as well as osmiridium. Only a very small portion of these extensive flats has been worked, and probably, as exploration goes on, other payable concentrations will be found. This ground may not prove payable for osmiridium alone, but with the added value of the other saleable products it is considered that success will attend the operators.

Up to the present time operations have been confined to the left bank of the Castra, above the point of junction with the Whyte. The workings, in granitic wash 3 to 8 feet deep, are jotted here and there over the plain from one end to the other. All the metals obtained here are of good grade and size. The tinstone is coarsely crystallised and comparatively free from impurities. Ruby, resinous, grey and black varieties are found. The monazite is of good quality, but rather fine in grain, and the osmiridium and gold associated with it are typical of the Loughnan Creek deposits.

On the north side there is a large unprotected flat covered with " horizontal " scrub. This is the flood-plain

PLATE VI



GEOLOGICAL SKETCH MAP OF HEAZLEWOOD DISTRICT

Photo Lithographed by John Vail, Government Printer Hobart Tasmania.

of Whyte River, and may contain metals of value. Whyte River has not been carefully prospected in its upper reaches, therefore it is impossible to estimate the value of the productive placer ground. Mt. Stewart tramway, between Castra and Whyte Rivers, passes through the centre of an old river-bed fully 20 chains wide. The gravels of this valley—at one time occupied by Castra River—have been worked in a desultory fashion for gold and tinstone.

Reports are current that rich concentrations occur at the junction of Heazlewood and Whyte Rivers. Credence cannot be placed in these statements, because no payable deposits have been found in the upper waters of either of these streams.

Castra Plain.—This plain is the centre of a granite amphitheatre, from which a means of egress is found through a narrow gorge to the north-east. Castra River flows in a great semi-circle, and passing through the gorge mentioned, continues in a general northerly direction for 2 miles, thence westerly to join the Whyte River. This plain marks the southern boundary of the Heazlewood sub-silica rocks, which are succeeded by the slightly posterior granites. It is noticed that the serpentines have suffered greatly from the effects of the intrusive granite, possessing now a peculiar baked appearance. In the river-bed the rock is seen in large tesselated plates, and is very brittle and flaky. Like all serpentine areas the plain is almost devoid of vegetation, stunted shrubs and coarse grasses and reeds alone finding sustenance thereon.

The serpentines here consist largely of altered pyroxenites, in which osmiridium is seldom found. A small area of peridotite crops out in a creek near the northern border. and from this rock the little osmiridium recovered here has been shed. Pot-holes have been sunk without success through limonite rubble into the bed-rock in all other quarters of the plain. Where the metal does occur it is so sparsely distributed through the detritus that its recovery is unprofitable.

Savage River District.

As far back as 1880 the sands of this river and its tributaries were worked for gold. In those days the presence of osmiridium added to the difficulties of the diggers in effecting a complete separation of the yellow metal from

its heavy associates, and for long it was regarded as a nuisance. It is only within recent years that these deposits have come into prominence again, this time on account of the osmiridium content and the gold is now regarded as an offensive associate of the osmiridium. The larger part of the mineral in Savage River obviously came from Nineteen-mile Creek, as very little indeed has been found above their confluence. Naturally, being so far from its source, the mineral here is much finer, however, the bulk of it is of nice grainsize, and commands the highest market rates.

The largest and richest deposits occur on the bed of the stream or on the sides near the water's edge. Remnants of old terraces still cling to the valley sides at various elevations, some of them hundreds of feet above flood-water level. The steepness of the walls of the valley precludes the possibility of their preservation in extensive masses. At the present time the river is being worked by 70 to 80 men over a distance of about 15 miles; but doubtless it is osmiridium-bearing down to the confluence with the Pieman. Beyond the deep waters of the river only the finest particles have been conveyed, and the deposits there are economically unimportant.

The river-bed, which is strewn with large conglomerate boulders, can be worked during the short summer season only. Floods are not infrequent, even at this time of the year, and the work is interrupted thereby. The general practice is to divert the water to one side by wing dams, while the wash and bottom dirt are being picked up and sluiced on the other. In some places old terraces are panelled, and the rich bottom dirt blocked out; in others the whole material is sluiced. The Savage River Gold Mining Syndicate has recently tunnelled 370 feet through the neck of a narrow spur at a sharp bend in the river, for the purpose of diverting the water from a long section of the river-bed. Unfortunately, this work was not completed in time to take advantage of the dry weather, and work has consequently been postponed until next summer. About October next the tunnel will be reopened and cleaned out, and it should then be possible to obtain four months work on the dry river-bed. Tests of the value of the ground drained by the diversion of the river have proved entirely satisfactory. From trial pits nuggets of gold up to 14 dwt. have been obtained, and the osmiridium values likewise appear very high. Near-by is an old elevated terrace of alluvial material containing 8 to 10 grains

of osmiridium per ton, evenly distributed throughout its mass. It is proposed to work this ground during the winter months.

Further down-stream Thurstun and Leary are panelling consolidated gravels just above flood-level. The bulk of the osmiridium here, as elsewhere, in such deposits is found near, and on the bed-rock. On the lower stretches of Savage River Valley there are a succession of gravel terraces on both sides of the valley corresponding in altitude with those observed in the valley of the Pieman, which have been deposited as the stream approached base-level. Subsequent slight uplifts resulted in successive cycles of rapid erosion, leaving these remnants high up on the valley sides. In addition to the gold and osmiridium derived from the osmiridium-bearing serpentines, the gravels of these terraces contain the gold shed from the Long Plain-Specimen reef line of ore-bodies, and also that brought down by the reworking of pre-existing Tertiary gravels, remnants of which still cover Long Plain, Brown Plain, and other elevated plateaux.

The gravels vary considerably in composition; the higher terraces consist of quartz and quartzite pebbles, intermixed with fine to coarse sand, but in the lower deposits there is much clayey material.

From the head of the Savage southward to the Pieman diggers have been at work since 1881, and a great deal of gold and osmiridium has been won. The most primitive methods have been employed, usually dishing and cradling; but hydraulicing on a small scale has been resorted to in a few instances. The higher terraces have been attacked only in a desultory fashion by panning and cradling at points where water is available. There is a very extensive field here for hydraulic sluicing, the ground being too poor to be treated in other ways.

Badger Plain Area.

Owing to the difficulty of access, and the short space of time available, this outlying portion of the Long Plain district was not examined. The area is rather extensive, and lies between Mt. Donaldson and Savage River. Badger Plain is part of the old Teritary peneplain, and was at that time occupied by a broad river flowing from the direction of Bald Hill. From information gathered it appears that the surface is largely occupied by soft Ter-

tiary conglomerates and alluvial materials, and in these are found osmiridium, gold, and diamond. The underlying rock is reported to be limestone and sandstone.

It seems probable that the Tertiary deposits here have been reworked by the action of Badger and Harvey Creeks and the several minor streams, for in them the concentrations are much richer. The absence of magnetite has been used as an argument in opposition to the opinion that the precious minerals were conveyed by way of Savage River channel. A point worthy of notice is that the rich deposits occur usually about the same level high up the western side of Savage Valley. Possibly this is due to the change in bed-rock from a good to a poor catchment.

These deposits are fairly extensive, but the easily-worked placers are nearly exhausted, and the large Tertiary placers are too poor to pay under present conditions.

WILSON DISTRICT.

GENERAL FEATURES.

The alluvial deposits of this district contain tinstone and gold as well as osmiridium, and some of them are of considerable extent. So far as is known they constitute the only deposits of value in the district, but exploration may yet reveal payable bodies of osmiridium *in situ*.

Developments date back to 1903, when C. Riley and W. Kinsella discovered osmiridium in paying quantities in Trinder Creek. Shortly afterwards J. T. Riley located osmiridium in foliated serpentine, about 25 chains northwestward of Riley Knob, and applied for a reward claim of 80 acres. Only the very richest deposits were payable at that time, and the market was so unreliable that operations ceased in 1905. The reopening of the markets at very much higher rates drew attention once more to the field. Among the particularly successful newcomers were J. Sweeney and J. Dooley, who found the largest nugget recorded for this district. Progress since 1910 has been remarkably rapid, and remunerative employment is now found for 60 men.

The district is easily accessible from Renison Bell by way of the Argent River route, and also by means of a pack-track leading off the Stanley River track, 20 chains north of the suspension bridge over the Pieman. There is yet another way by which the district may be reached, namely, the Huskisson River route from Rosebery.

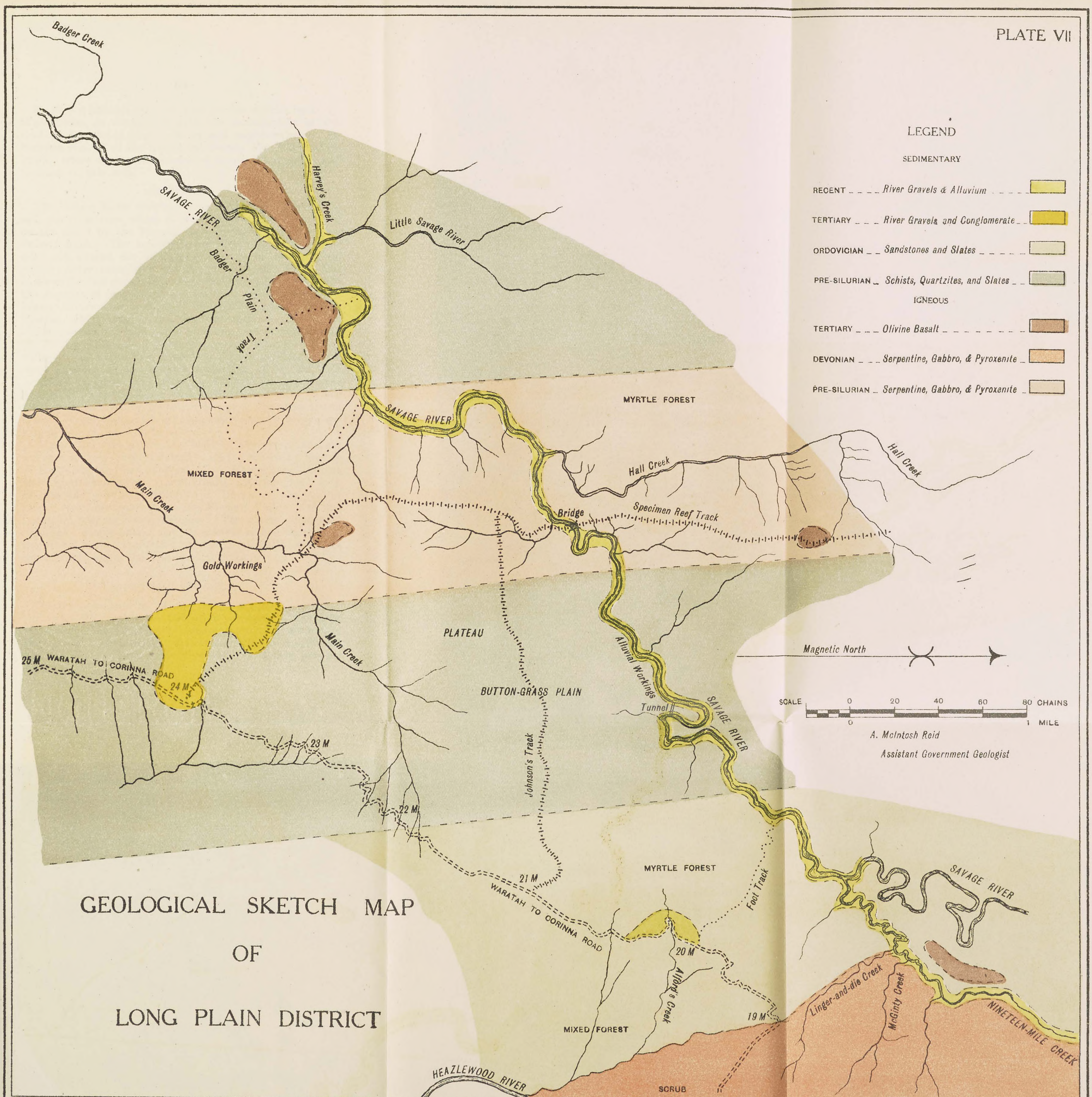


Photo Algraphed by John Vail Government Printer Hobart Tasmania.

In 1913 a hurried visit was paid to this district by L. L. Waterhouse, in connection with the examination of the tinstone deposits of Stanley River and neighbourhood. In Bulletin No. 15 of the Geological Survey Mr. Waterhouse briefly refers to the occurrence of osmiridium, gold, and tinstone in this area.

TOPOGRAPHY.

The Wilson River district, lying between the Huskisson and the river from which it receives its name, is bounded on the south by the Pieman, but on the north it has no defined limit. The accompanying sketch-map (Pl. VII.) does not extend far enough northward to embrace the country intervening this and the Heazlewood district, but it shows the full extent of the igneous intrusives from which the deposits of osmiridium are derived. Wilson and Huskisson Rivers flow southward on parallel courses to the Pieman, which has a general westerly trend.

The present subdued surface outlines are largely due to the erosive action of glaciers which once occupied all the valleys. In Pleistocene time the valleys of these rivers were occupied by ice tongues extending up to the high mountain ranges. The most prominent feature of the district is Parson's Hood, the southern extremity of the great granite mass of Meredith Range. The interstream area is largely occupied by comparatively low serpentine ridges with rounded surfaces.

About 350 feet above the beds of the rivers are old terraces covered with morainal material consisting largely of enormous boulders of West Coast Range conglomerate and quartz-porphyry (porphyroid) intermingled with granite and granite porphyry of Devonian age. The former were conveyed down the Pieman Valley, and the latter by way of the Huskisson. The rivers since that time have deeply entrenched themselves in the bedrock of the glacial valley, occupying narrow, steep-walled channels considerably above the base-level of erosion.

GENERAL GEOLOGY.

On the west side of Wilson River schists, slates, and quartzites of probable Pre-Cambrian age occur. The chief varieties of the schists are biotite, muscovite, actinolite, and quartz. Their strike varies from 300° to meridional, and the dip is north-easterly at 80°, to nearly perpendicular.

Unconformably overlying these strata to the eastward is a series of slates, sandstones, and tuffs, with intercalated igneous rocks. This series is continuous with that developed at North Dundas, which is provisionally placed in the Ordovician. The average strike is 310°, and the dip is south-westerly at about 75° The sequence of this and the next succeeding formation is interrupted by the serpentinised gabbro dyke-rock, occupying the interstream area. The Silurian sedimentaries on the other side of the dyke differ from the preceding in many particulars. They consist of soft, somewhat friable sandstones, soft greenish-grey to blue slates and compact, dark, argillaceous limestones, all of which contain abundant fossils characteristic of the period. Their strike varies from 260° to 280°, and their dip is northerly at inclinations between 60° and 80°. It is probable that the intrusion of the gabbro dyke has affected the true strike and dip considerably, and these readings, therefore, may not represent the normal position. The order of succession of these beds from the serpentine is: slate, 20'; sandstone, 100'; greenish-grey slates, 200'; blue slates, 400'; sandstones in flags, 1400'; and, finally, blue fissile slates extending beyond Huskisson River. It is noteworthy that only near the point of junction between one member and another are fossils very abundant. The fossils have not yet been precisely identified, but among the determinate remains Rhynchonella borealis, Orthis, Tentaculites and Orthoceras were found. Very good impressions of undetermined Trilobites are common, as are also certain discoidal imprints.

These Silurian strata are penetrated by several narrow dykes of quartz-felspar porphyry, the trend of which is parallel to that of the relatively large gabbro dyke. From these rocks the grey, brown, and ruby tinstone occurring here has been shed.

By reference to the geological map it will be perceived that the limestone member of the Silurian formation shows a series of horizontal displacements, each of which is about 2½ miles in extent. These displacements have been brought about by thrust faulting on a vertical plane, the direction of thrust being south-easterly. This is one of those rare occurences of horizontal displacement on a large scale. The faulting is directly due to the intrusion of the igneous rocks.

The igneous rocks, already referred to, consist of three classes, namely—extremely femic, dominantly femic, and

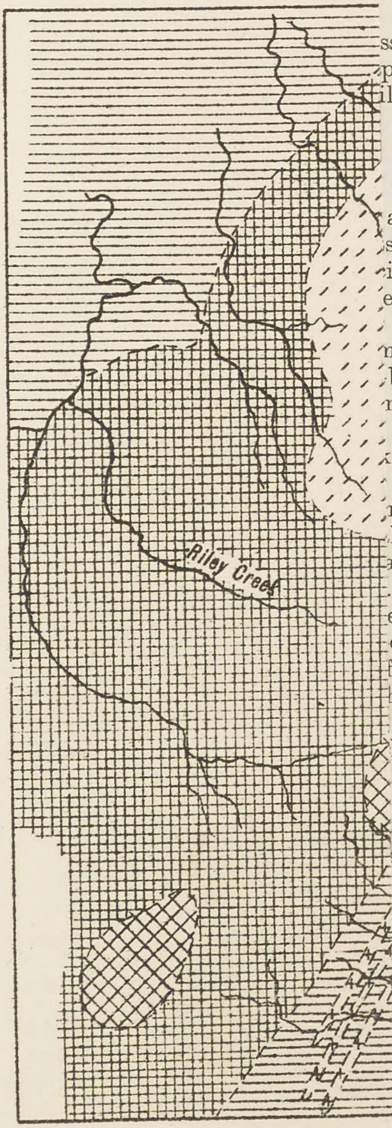


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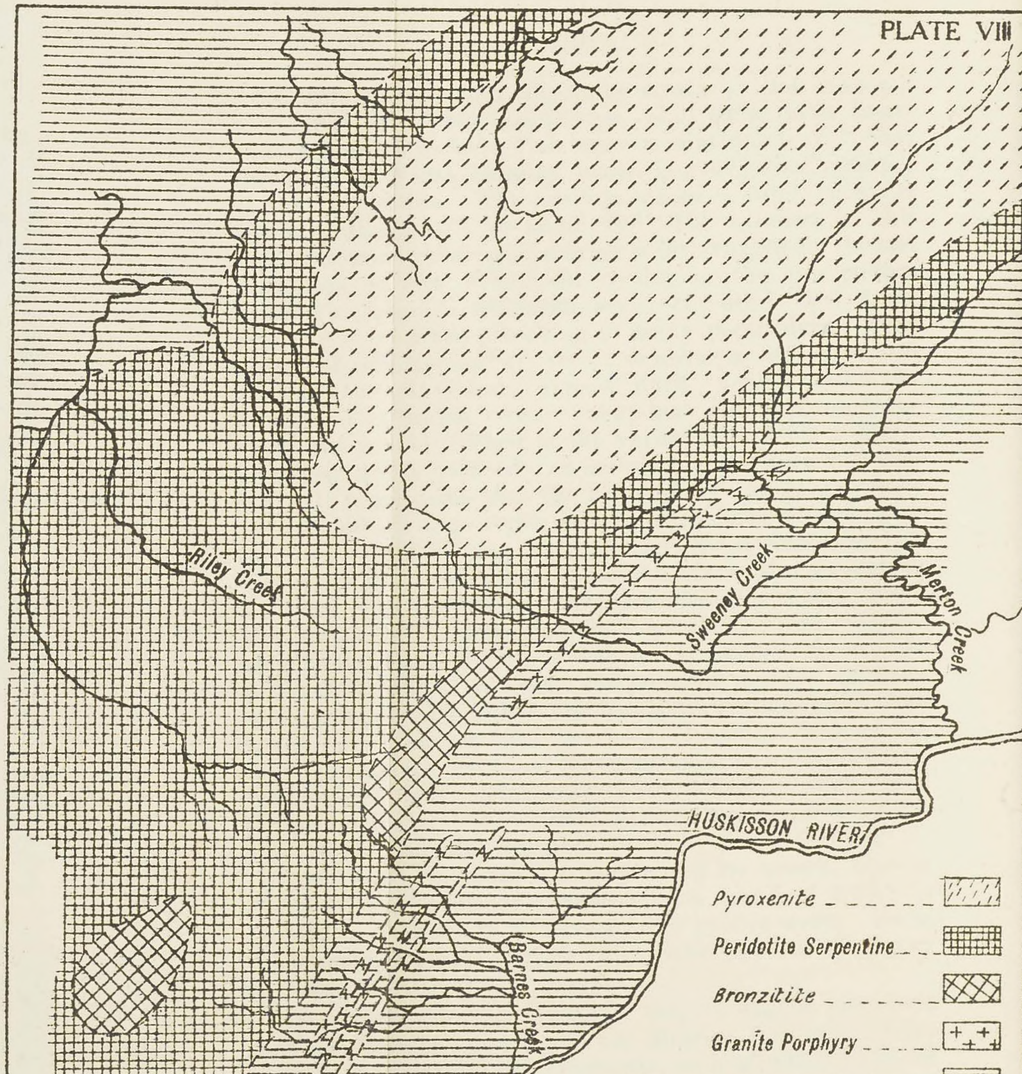
PLATE VIII


Riley Creek
Sweeney Creek
Merton Creek
HUSKISSON RIVER
Barnes Creek
Pyroxenite
Peridotite Serpentine
Bronzitite
Granite Porphyry
Slates Limestones and Sandstones

salic; represented by serpentines, diorites, and granites respectively. The rocks typical of these classes have been described in some detail in an earlier chapter, and the differentiation of the gabbro magma is illustrated by Plate VIII.

Osmiridium Deposits.

Riley Creek.—Originally worked by J. T. and C. Riley, after whom the creek is named, these deposits have proved wonderfully rich. They are not merely surficial concentrations, like so many of those found in the beds of creeks, but are deposits derived from the underlying serpentinised bronzitite and peridotite rocks. The bottom of the valley is 5 to 8 chains wide, and is osmiridium-bearing right across, but only a narrow strip about a chain wide and a mile long, comprising the central channel, has received attention. The detritus, 2 to 6 feet thick, consists of limonite rubble in discoloured steatite resting in places on a floor of white talcose material, which, in turn, gives place to soft serpentinised bronzitite. The removal of the soft decomposed cover has revealed large structural planes and transverse contraction joints in the serpentine. The fillings of these planes was the original home of the osmiridium shed in the creek. Near its upper end the creek enters one of these crevices and emerges about 700 feet further down the valley. Prospecting operations along the course of these planes is strongly recommended. In the detrital material the richest osmiridium is near bedrock, commonly in potholes and shallow depressions in it, and as a rule is coarse and even nuggety in form. Some of the crevices in the bedrock have been cleaned out to a depth of 6 feet, and the steatite fillings extracted in the operation yielded excellent returns.

It seems incomprehensible that no sustained attempt has been made to quarry the rock in order to get at the rich interstitial material. Nowhere are there better prospects for successful operation by this method than are presented here, where the geological conditions are decidedly favourable.

Conglomerate Plain.—This is a button-rush-covered plain on the right bank of the Pieman, between the Husskisson and Wilson Rivers. It forms portion of the preglacial bed of the Pieman, above which it is now 280 feet, and about 480 feet above sea-level. The surface is largely occupied by glacial morainal material, consisting of enor-

mous conglomerate and schistose-porphyry boulders derived from West Coast Range formations many miles to the eastward. The presence also of tin-bearing granites in considerable abundance shows that this is the point of confluence of the smaller Huskisson glacier with the larger one flowing down the valley of the Pieman. In their movements towards the sea these glaciers spread over the serpentine hills, reducing their irregularities and leaving behind enormous erratics and morainal debris as evidences of their actions. This glacial debris contains much comminuted serpentine material, with included osmiridium and gold. Tinstone, evidently conveyed down the Huskisson channel with the Devonian granites, is sparsely distributed through the mass. Portion of it, however, may have been derived from the underlying porphyry dykes. Excepting where small streams have reworked and concentrated the valuable minerals, these deposits are unpayable. Such concentrations occur in Sailor Jack, Porphyry, and Holland Creeks, from which fairly rich recoveries have been made.

Several small streams (numbered 1 to 5) west of Conglomerate Plain flowing northward into Riley's Creek contain rich concentrations of gold, tinstone, and osmiridium. The deposits are not at all extensive, and evidently are remnants of the Huskisson River series of alluvial gravels. The wash, consisting largely of quartz-tourmaline and granite sands and pebbles, rests in some places on a yellowish-brown to greenish clayey rock derived from the decomposition of diorite, and in others on a bluish-black Silurian slate. On the ridges between these streams only small traces of the valuable minerals have been found, and the rich gravels extend about 15 chains only up-stream.

Trinder and Fowler Creeks are other sources of osmiridium and gold in this locality. Their metallic mineral deposits have been derived from the peridotite formations north-west and west of Riley Knob, and from the reworking by these streams of glacial debris.

Three-mile Creek, emptying into the major stream from the north, has also produced a fair quantity of good-grade metal. It is rather extraordinary that below this point the deposits in Riley Creek are very poor.

Kershaw, Roberts, Biscuit, Berkery, Jones, and Gould Creeks, having their sources on the west side of Serpentine Ridge, are tributary streams of Wilson River. All of these streams are producing fair quantities of " metal " and

gold. The bedrock is soft serpentine near the headwaters, succeeded lower down-stream by slates and diorites, which, near the point of contact, are slightly schistose. There is very little " wash " in these streams, which are fast-flowing, and occupy narrow steep-walled gorges. The osmiridium and gold are usually of fairly fine grainsize, and appear finer and scarcer as the deposits are further and further from the serpentine.

So far as is known there is very little osmiridium in Main Creek, and lower Wilson River deposits are very poor.

Limestone Creek.—This stream flows north-westward along the north-eastern boundary of the serpentine formations, and empties into the Wilson River at a sharp bend below Websterite Hill. The bed of the creek is occupied by Silurian limestone, striking 288° and dipping northerly at 65°. For some distance the stream follows the strike of the limestone, which is exposed in long combed ridges. In places the waters enter caves, 20 feet deep, emerging again near the river. At the point of contact the puggy material resulting from the decomposition of the argillaceous limestone is so soft that a stake may be driven 20 feet into it without difficulty. On the surface of this puggy material, and also in crevices and depressions in the compact limestone, the osmiridium and gold have been collected. These minerals occur here in about equal proportions, and in places in very rich concentrations. It is interesting to note that the gold is commonly found crystallised in reticulated and filiform shapes; sometimes in thin threads 3 to 4 inches long, and twisted as if by hand. Specimens showing gold attached to, and even completely enclosing, osmiridium are not uncommon. In addition to these forms it occurs in flattened scales, and more rarely in rounded ovoid nuggets. In appearance it is lighter in colour than that so commonly found in association with osmiridium. Analyses show that the lighter shades are due to the presence of silver. Specks of galena and pyrite are frequently observed in the rock. Evidently at this point the segregation of the metals reached the border of the intrusive basic rocks.

At the confluence of Limestone Creek and Wilson River a limestone bar extends right across the latter, providing an ideal catchment for metals of high specific gravities. It was intended to divert the river into a channel cut through the narrow point, but it was found that the cost

of draining the river-bed would be so great as to make the venture too hazardous. The river wash in the banks contains osmiridium, and a little further down-stream it contains gold in payable quantity. Above this point the metals are too sparsely distributed through the wash to pay for recovery, indicating that the lower deposits were derived largely from Limestone Creek.

Just south of Limestone Creek is an unnamed stream heading out of a broad basin. It is stated that rich sluicing-ground occurs, and that the scarcity of water is the only obstacle to its exploitation.

Ahearne Creek and the several small streams in the vicinity have all produced fair quantities of metal. The supplies have been drawn from puggy soils, 2 to 3 feet deep, resting on serpentinised peridotites. The available detritus is of very limited extent.

Tobin Creek, flowing into Alfred River, a tributary of the Wilson, about a half-mile north of Limestone Creek, is also another source of osmiridium. Good prospects of " shotty " grade were obtained at several points down-stream below the road. There is room here for several sluicing claims.

About a mile northward of this point a stream has been worked for tinstone and osmiridium. These are the most northerly workings in the Wilson district.

Harman River Gravels.—Between the Wilson and Harman Rivers, above their confluence, is an extensive deposit of alluvial river gravels. These gravels carry, sparsely distributed through their mass and more abundantly near the bottom, gold, tinstone, and osmiridium with associated chromite. There are many conflicting reports about these deposits. Some state that here are rich accumulations, others aver that the alluvial is too poor to treat successfully. The reconcentration of the metallic components of these gravels by creeks cutting through them have resulted in the formation of local enrichments of small extent.

Keenan Creek, flowing due east into Wilson River, forms the extreme northern boundary of the serpentine formations. The contact-rock at this point is Silurian limestone, and represents the lateral displacements of the Limestone Creek formations, due to the intrusion of the basic magma. The bed and banks of this creek have been worked for a mile above its mouth, and have produced high-grade metal in paying quantities. The occurrence of gold here is exactly similar to that at Limestone Creek.

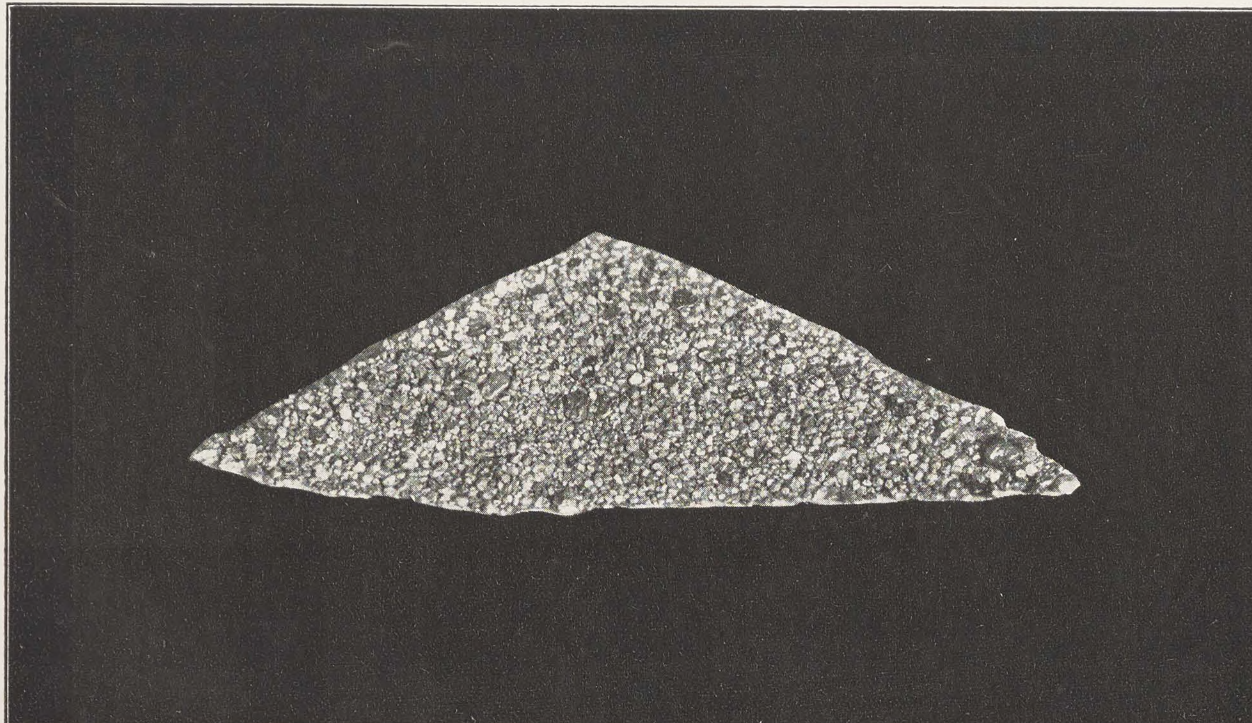


Photo. 11.—"POINT METAL" OSMIRIDIUM, WILSON RIVER FIELD. (Nat.) [A. M. Reid, Photo.

To face page 74.

Riley Prospect.—Osmiridium was discovered here in serpentine detrital material many years ago. Since then schlieren in foliated serpentinised peridotite have been uncovered by the removal of the thin mantle of soil, and a considerable amount of metal has been extracted therefrom. The strike of the serpentine here is 25°, and the dip south-easterly at an inclination of 68°.

The schlieren or pockets, 1 to 2 inches wide, and 12 to 20 inches long, are very irregularly distributed along the planes. One such, cleaned out at the time of this examination, contained coarsely crystallised grains of osmiridium in a matrix of limonitic steatite. Occasionally specks of osmiridium are found in the wall-rock, but such occurrences are unusual, and the serpentine between planes is comparatively barren. From a block of ground 60 feet by 30 feet by 2 feet over 20 oz. of metal have been recovered.

Between these workings and the western edge of Riley Knob the surficial material at several points has been treated more or less successfully. One small patch in particular near the north-west edge of Riley Knob has yielded very rich returns, and probably the whole of this would pay to crush and concentrate.

Huskisson Valley Area.

This area has been neglected for long, because it is comparatively inaccessible, and because the eastern side in particular is covered with an impenetrable tangle of "horizontal" scrub. On the western side several tributaries are now being worked, and are contributing largely to the output of the district. On the other side prospecting has been confined to Chromite Creek, which has yielded osmiridium, gold, and tinstone. No sustained attempt has been made to prospect the river-bed, so that it is impossible to state whether or not it contains metal values in payable quantities. There is here a very large field for investigation, and one, perhaps, which may well repay the diligent prospector.

On the western side the tributaries have their sources in Serpentine Ridge, and the metals are directly derived therefrom; but in the bottom of the valley and the terraces on the east side the gravels are largely composed of granite, and have been conveyed many miles from a quite different source. The gold, tinstone, and osmiridium

obtained from these placers are fine-grained, and show much evidence of attrition.

The Huskisson valley gravels have been divided into three plains that rise one above another in the form of terraces. The uppermost of these terraces is that represented by the glacial debris of Conglomerate Plain, and the elevated gravels on the east side of the valley. These are very extensive accumulations, but are comparatively poor in mineral content.

Along the inner margin of the glacial deposits, and confined to the present valley of this river, is a second terrace of much greater economic import. This terrace extends up the valley for many miles, and on the east side in particular occupies a very large area. The terrace is represented now by discontinuous remnants having been dissected and eroded by numerous tributary streams of the Huskisson. Only one of these streams, named "Chromite Creek," has as yet been worked for osmiridium. Several others to the north and south are known to carry equally rich concentrations. The materials of the gravels consist largely of quartz, granite and porphyry, quartz-tourmaline, sandstone and slate, and rest on slate bed-rock.

The third and lowest terrace is only a few feet above present flood-level. The thickness of these gravels ranges from 4 to 20 feet; their extent is considerable, but undeterminable owing to the irregularity of their outline. Their composition and content are essentially similar to those of the higher terrace.

Merton Creek.—This creek is formed by the confluence of Osmiridium and Christina Creeks, which receive their waters from the western fall of Serpentine Ridge. One-half-mile down-stream its two major tributaries enter—Sweeney Creek from the south, and McArthur Creek from the north. The main stream follows an extremely irregular course in an eastward direction for 3 miles before emptying into Huskisson River.

Up to the present time this stream, with its affluents, has produced more osmiridium than any other tributary of Huskisson River. The rocks exposed in its channel are Silurian limestones, sandstones, and slates, and narrow porphyry dykes. Into the cleavage-planes of these rocks osmiridium and gold find their way, and by the action of flowing water are concentrated in payable deposits. The clayey residuum from the decomposition of argillaceous

limestones and felspathic porphyries formed a safe catchment for the heavy metals, and such spots, in particular, have proved especially rich. The bed of this creek has been worked in patches from one end to the other, the unworked ground being of inconsiderable extent and much lower value. Both osmiridium and gold occur associated with a little tinstone and abundant chromite. In addition, specimens showing gold on one side and platinum on the other have been repeatedly noted. These metals are contained in wash consisting of porphyry, gabbro, pyroxenite, sandstone, and quartz.

Crossing Merton Creek about a mile above its junction with the Huskisson are two veins of quartz about 6 chains apart, coursing 10 to 15 degrees east of north, and cutting across the bedding-planes of the slates and sandstones. They are 1 to 3 feet wide, and continue unbroken at least 10 chains, and apparently are quite barren of economic minerals.

On the flat between McArthur and Christina tributaries are very shallow deposits of clayey alluvium containing tinstone. The extent is very small, and the deposits only 1 to 2 feet deep.

Osmiridium Creek flows northward along the eastern border of the serpentinised intrusive. Its channel has been cut through deep puggy alluvium containing fair osmiridium values very irregularly distributed. This puggy material consists almost wholly of decomposed serpentine up to 8 feet deep in places. It is singular that the metals here are distributed through the decomposed mass and the bed-rock is comparatively barren. Near the source of this stream the watercourses contain coarse-grain metal, some specimens weighing over 1 dwt., and one over 1 oz. A little platinum attached to gold is found occasionally. In addition to the precious metals, grey, brown, and ruby tinstone is recovered. This mineral is shed evidently from the porphyry dyke, which intrudes Silurian sandstones a few chains to the eastward. There is a fair extent of unworked alluvium here, but very little water is available for washing. Rich pockets of metal have been found in the master-joints in the serpentine near the border.

Sweeney Creek.—Sweeney Creek is a tributary of Merton Creek, and is only about a mile long. Its source is in Serpentine Ridge on the eastern side, but the greater part of its passage is over stratified rocks which are penetrated by

narrow porphyry dykes. The valley is comparatively broad and the stream is slow-flowing, consequently the alluvial consists largely of finely comminuted material derived from the disintegration of serpentine. The bottom wash, however, is much coarser and is varied in its components.

The largest nugget of osmiridium found in the whole Wilson River district was recovered by Jas Sweeney near the source of this creek. This specimen was purchased by the Department of Mines for £30, and is now stored at the Geological Survey Offices, Launceston. By far the richest deposits occur in the upper reaches; down stream the osmiridium is fine-grained and covered with 4 to 5 feet of barren clayey material. Below the big marsh some very rich patches have been worked, but these deposits were very small. Pot-holes sunk in many parts of the marsh show up to 6 feet of peaty material over the wash, which is about 2 feet deep and consists largely of granitic and quartzose pebbles. The osmiridium content is small and erratically distributed. Higher up stream, besides the large nugget, J. O'Meara and W. Knight found other pieces weighing over 1 oz. Near the point where the track crosses Sweeney Creek rich pockets of metal are likely to be met with in the master-planes. The eastern fork of Sweeney Creek has been named Gold Creek, on account of the high proportion of gold contained in the concentrate The deposits here, although fairly rich, are small and unimportant.

Christina Creek is wholly contained in serpentinised pyroxenites, and about 30 chains from the border. The wash and detrital material are comparatively poor in consequence. McArthur Creek flows south-eastward a few chains inside and parallel to the border of the serpentine. Its channel for a mile is cut through deep clayey alluvium resting on a foot or two of wash containing osmiridium and gold in payable proportions. A large quantity of metal has been recovered from the bed of this stream, but these deposits are now nearly worked out.

Tin Creek is a torrential stream flowing eastward, and empties into Huskisson River about a mile below Merton Creek. Its channel is cut through greyish-green calcareous slates and bands of crystalline limestone. The wash, consisting largely of glacial conglomerates and grits, sandstone, quartz, and porphyry, contains fair values in osmiridium and gold. It owes its name to the occurrence of greyish-brown tinstone in considerable abundance, derived evidently from the narrow dykes of quartz-felspar porphyry

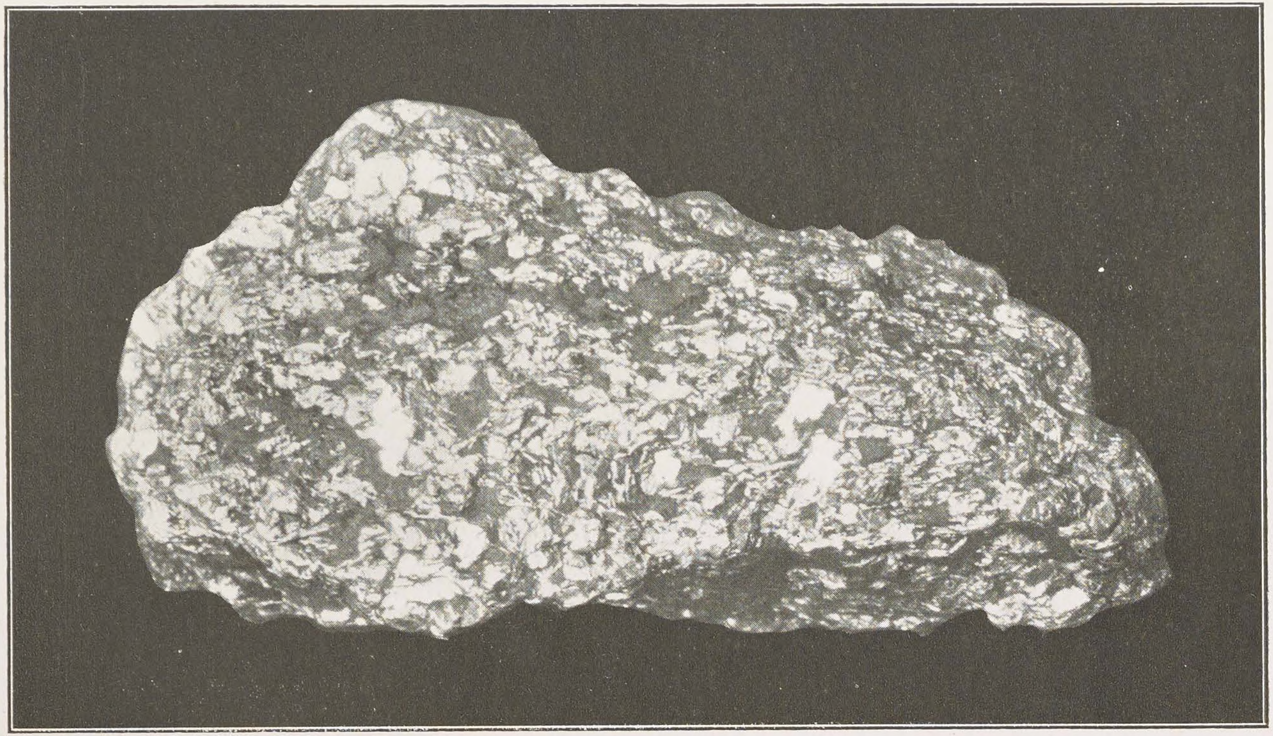


Photo. 12.— "SWEENEY" NUGGET, WILSON RIVER FIELD. [A. M. Reid, Photo.

Weight, 1 oz. 19 dwt. $7\frac{1}{4}$ gr. (2 nat.)

To face page 78.

which outcrop here and there in the vicinity. In the bed of the stream are botryoidal masses of limonite deposited recently from solutions traversing the limestone formations.

Barnes Creek is an inconsiderable stream emptying into the Huskisson from the eastern edge of the serpentine belt, a mile south of Tin Creek. With its tributaries, Carpenter, Hill, Bealey, and King Creeks, its source is in the peridotite rock north-west of Riley Knob, whence the bulk of the osmiridium found on this fall has been shed. It cuts through glacial morainal material near its source, and through Silurian slates, limestones, and sandstones and narrow porphyry dykes, covered with recent fluviatile deposits, lower down stream. This stream and its affluents have been worked from the mouths upwards, and gave good returns in osmiridium, though they yielded little gold. The wash consists dominantly of water-worn granite, quartz-tourmaline, and quartz, resting in places on a soft white bed of kaolin, and contains tinstone throughout. This wash belongs to the Huskisson River terrace deposits, and probably portion of the osmiridium concentrated in these small streams has been derived from these river gravels by reassortment. The banks of these streams contain very little values in gold and osmiridium, and in the beds the metals are found in the bottom wash and bedrock only. Some of the osmiridium found in these creeks is dull-coloured, resembling tarnished bismuth. In grain it is fine to coarse, but preponderatingly fine. The gold is sometimes coarse and flat-shaped with rounded edges. There is even yet a fair amount of unworked rich material in this area.

Further southward there are several other small tributaries of the Huskisson. All of them contain the precious metals, but not one of them in payable quantities.

Chromite Creek.—The source of Chromite Creek is in a button-rush plain about 550 feet above sea-level, and apparently the bed of a former Tertiary stream. It flows for 2 miles in a south-westerly direction, and empties into the main channel about a mile below the mouth of Merton Creek.

The concentrations in this channel have been formed by the reworking of the older terrace deposits, which have been completely dissected to bedrock. Wire gold, osmiridium of fine grainsize, and black, resinous and ruby tinstone are found here in intimate association. These minerals are found in the bottom wash and embedded in the underlying slate accompanied by perfectly crystallised

chromite and picotite in great abundance. A small amount of the valuable metals is contained in the top wash. It is quite evident that portion of the gold in these gravels is derived from formations in the vicinity, as wire-like specimens from $\frac{1}{4}$ to $\frac{1}{2}$ inch long are commonly found with fine and coarse grained scales. The tinstone occurs in particles as large as pease, but usually fine, and osmiridium in shotty form is occasionally recovered.

The operators had ceased work at the time of this examination. From indications very little ground has been worked, although tests of the gravels showed that sluicing operations could be successfully conducted. These deposits will never be remarkable for extraordinary yields of osmiridium, gold, and tinstone, yet they will provide a good source of income for capable men. There are enormous quantities of material awaiting treatment in this locality. The high-level terraces have not yet been prospected. A few pannings of the top wash gave disappointing results, but the values below the surficial material have not been revealed. Outside the valley of Chromite Creek no exploratory work has been carried on at all.

In working these comparatively low-grade deposits old methods should be abandoned, and hydraulicing on a large scale instituted.

Near the great bend in the course of Huskisson River is an outcrop of serpentine and gabbro extending southward towards Colebrook. Osmiridium in very small quantities has been discovered in creeks leading from this belt at several points. The predominating gabbroid character of the rock at the area examined, however, does not encourage the idea of payable occurrences in that locality, but the rock type southward may vary and better results may be obtained in that direction.

Renison Bell District.

Immediately northward of the township of Renison Bell is the old flood-plain of Pieman River as it appeared in Pleistocene time. This old plain, which is now between 200 and 300 feet above the present bed of the river, is covered with alluvial material of variable character and from 1 to 12 feet in depth. Osmiridium and gold of fine grainsize are fairly evenly distributed through the wash; but, unfortunately, not in sufficient quantities to prove of any great economic importance. On the fall towards the river numerous tributary streams heading from the plain by

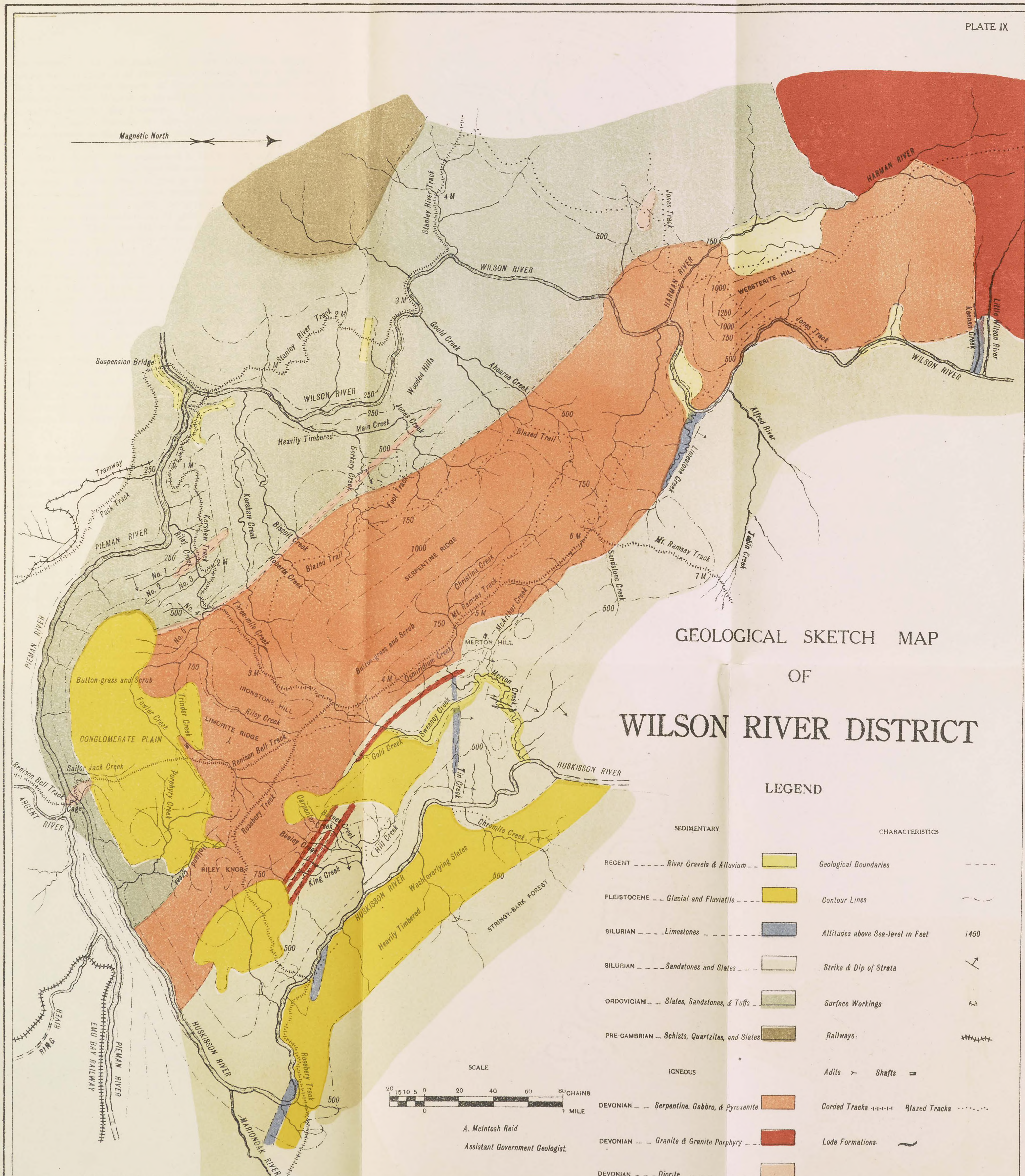


Photo Algraphed by John Vail, Government Printer, Hobart, Tasmania.

the reworking of the materials of the alluvium, contain richer concentrations of the precious metals. It is probable that a contributing source of these metals is the southern extremity of the Wilson dyke of femic rock which is known to extend beyond the Pieman.

The greatest obstacle to the successful exploitation of these deposits is the lack of a sufficient water-supply and the difficulty in its conveyance to such a high elevation.

About 4 miles to the westward is Melba flat, a serpentine area from which a considerable amount of gold has been recovered. In this locality gold is the predominant mineral and osmiridium is quite subordinate. Although of no economic importance, this occurrence is interesting in emphasising the association of gold with rocks containing hornblende. This association has been repeatedly noted, not only here, but in many other parts of Tasmania.

Eastward of Renison Bell, beyond Ring River, a broad dyke of femic composition and variable lithological type follows the western flank of Colebrook Ridge. This dyke rock is a pale to dark green serpentine of peridotite and norite types, studded with minute octahedra of chromite, which on weathered surfaces stand out in relief. From this outcrop of serpentine osmiridium and gold have been liberated, and by the sorting action of water have been concentrated in stream beds. One of the richest of these deposits is that in Star Creek, a tributary of Ring River. Here, osmiridium, gold, and tinstone occur in assciation. The deposits in this and neighbouring creeks are almost worked out, but other deposits, of limited extent, may be discovered in this locality. The concentrations of osmiridium in Ring River are inconsiderable.

Dundas District.

In the township of Dundas a little osmiridium and gold is being recovered from concentrations in stream beds. The great serpentine belt extends through this area to the western fall of Mt. Dundas. A careful exploration of the area may reveal richer deposits, for peridotite occurs in fairly large bodies.

The Gordon District.

Preliminary Statement.

From time to time reports have been received by the Geological Survey concerning the occurrences of osmiridium-bearing serpentines in the valleys of the Styx,. Floren-

tine, Weld, Serpentine, and Boyes Rivers. It was known that the outcrops were not extensive, and that the deposits there were, probably, not of great commercial value, but they were considered of sufficient importance to justify the undertaking of a detailed examination. Accordingly the writer was deputed to visit these areas and prepare plans and reports of his investigations.

ACCESS.

The region is accessible by horse-track from Fitgzerald, the terminus of the Tyenna railway, which junctions with the Derwent Valley line at Glenora. From Mayne's farm, 6 miles west of Fitzgerald railway station, the track has a general westerly course for 36 miles to Serpentine Valley; thence it turns northerly, and continues in that direction for 10 miles to Gordon River crossing. It passes along the foothills of a great series of mountain ranges which divide the watersheds of the Derwent, Huon, and Gordon Rivers. The route is well chosen, nowhere exceeding an elevation of 1800 feet above sea-level, but the grades could be greatly improved by slight deviations here and there from the present line. Up to to the 14-mile peg (measured from Rolls' farm) the track has been cleared recently, and is in very fair order; thence to the 29-mile it is blocked by fallen trees and young scrub, and is generally in a state of disrepair. In its present condition it is impassable by horse, and only with extreme difficulty and inconvenience is it passable by the pedestrian. In addition to the personal discomforts incidental to expeditions through such mountainous country, the climate is most severe during the winter and the ground is completely covered with snow for considerable periods.

TOPOGRAPHY.

This region is one of the most rugged portions of Tasmania. It consists of a series of high mountain ranges trending in a general north-westerly direction, with broad intervening valleys possessing abundant evidence of Pleistocene glaciation. The valleys are from 900 to 1200 feet above sea-level, and the mountain peaks and ranges rise 3000 to 3700 feet higher. This is the gathering ground of many large tributaries of the Gordon, Derwent, and Huon Rivers, which have accentuated the topographic relief by the corroding effect of their waters.

Many of the higher peaks are capped by erosion-resisting diabase, and the long serrated ranges are crowned by equally resistant quartzites and conglomerates.

GENERAL GEOLOGY.

This region is occupied chiefly by Palæozoic rocks ranging from Lower Algonkian to Permo-Carboniferous. The Algonkian formations occupy the surface from the 28-mile peg westward beyond Frankland Range, and consist of foliated and sericitised quartzites and micaceous schists. These rocks are too much metamorphosed for complete identification, but apparently they are of sedimentary origin. They have a general south-westerly dip, and have been compressed into irregular folds with north-west axes.

Apparently reposing unconformably on the Algonkian formations is a series of pebbly sandstones, conglomerates, and quartzites, with intercalated slates and softer sandstones, which have been indefinitely ascribed to the Cambro-Ordovician. Their dip is variable, but a north-westerly direction appears general.

East of this series, between the 14 and 11 mile pegs, are two belts of grey limestone with black sericitised calcareous slates. This limestone is sparingly fossiliferous, containing obscure casts of minute crustacean remains resembling certain astracods, on which identification the formation has been tentatively placed in the Ordovician proper. The true structural relationship of this to the preceding formations could not be deciphered. They may be faulted against those beds or occupy synclinoria in them. These old strata have been intruded by Devonian ultra-basic igneous rocks of the peridotite and pyroxenite types, now completely serpentinised. Eastward of the limestone country as far as the 7-mile peg lies another area of the Cambro-Ordovician formations in which are contained the Mt. Humboldt copper mines.

Sandstones and mudstone-conglomerates of the Permo-Carboniferous system prevail from the 7-mile to Tyenna. They occur at several elevations indicating downthrow to the eastward.

Glacial morainal material of Pleistocene age is scattered here and there over the whole region.

Diabase of Upper Mesozoic age occupies the summits of Mts. Mueller, Wedge, Ragged, Anne, Wherrett's Look-

out, and Mt. Field West. It rests on quartzite at Anne, Wedge, and Ragged Mountains, but at the others it is underlain by Permo-Carboniferous strata, and occurs in the form of sills.

At Mayne's farm and properties adjacent thereto are thin sheets of the familiar Teritary basalt so common to many parts of the country.

Osmiridium Deposits.

Fourteen-mile Creek and Styx River.—This creek is crossed by the South Gordon track at 2½ miles from Mayne's. The wash in its banks contains a little gold, considerable chromite, with pink pebbles of garnet and fine, flaky specks of osmiridium, and consists of sandstone, quartzite, biotite granite, and quartz-felspar porphyry. No serpentine stones were seen in the creek-bed, but the osmiridium and chromite, and probably the gold, originated from that rock. This deposit of osmiridium is of no economic importance, and is evidently derived from the same serpentinised ferromagnesian formation as those exposed in the bed of the Styx River. The latter occurrence is reached by turning due south, from the 4-mile peg and crossing two high east-west ridges which separate the watersheds of Fourteen-mile Creek and Styx River. These hills are composed of a massive conglomerate, through which the river has carved its valley, exposing to view a small section of ferromagnesian rock now completely altered to serpentine. The rock is massive and dense, light to dark green in colour, and carries disseminated grains of chromite. The microscopic structure is that of a peridotite, in which the chief constituent was olivine. It is reported that other small outcrops of serpentine occur in Jubillee Range and Weld River.

In the Styx River sands gold and osmiridium, accompanied by their congener, chromite, are found, and several small parcels of good grainsize and quality have been produced from this source. The exposed area of serpentine is too small to admit of large accumulations, consequently it is notanticipated that either rich or extensive deposits will be found.

Florentine River Deposit.

At the 17-mile peg, about a mile beyond the Florentine River, a belt of intrusive ferromagnesian rock converted to

serpentine occupies the surface. Its actual dimensions could not be accurately determined owing to the deep soil cover and the almost impenetrable undergrowth of scrub, but it has been ascertained that it extends nearly half a mile in a north-westerly direction, and is fully 10 chains in width. Its trend coincides with that of Boyes' River occurrence on the other side of the Gordon, and probably they are projections from one subjacent body.

The rock is greyish-green to dark green in colour, in places foliated and fibrous, and showing slickensided surfaces due to differential movements during and subsequent to serpentinisation. Chromite grains are disseminated through the rock, and are extremely abundant in the detrital material resulting from its disintegration. Microscopic examination of the rock shows a predominance of pyroxene over olivine components. In order to test this rock for osmiridium deep pits were sunk, at points near the bed of a small creek flowing over the outcrop, through clayey material containing disintegrated serpentine and quartzite. Down to a depth of 5 feet osmiridium and gold of extreme fineness only were recovered; thence to 7 feet, flaky particles of much coarser grain were found. The actual value could not be determined, as it was impossible to reach bedrock owing to influx of water. However, like Styx occurrence, the deposit is of small extent, and the output therefrom will not appreciably affect the total production.

It is noteworthy that in Florentine Valley, a mile to the eastward, chromite is extremely abundant in the river sands, but whether derived from this or some other source could not be determined.

Serpentine River Area.

This area consists of a very broad, button-rush-covered plain, bounded on the west by the Frankland and Wilmot Ranges, and extending from Lake Pedder to Gordon River. The slow-flowing Serpentine River meanders in a remarkably sinuous manner down the centre of this great, glacial plain, and empties into the Gordon at the intersection of Wilmot and Hamilton Ranges. Old exploratory charts contain records of the occurrence of serpentine rock in this valley. Credence was given to this identification by the reported discovery in the locality of a mineral possessing the physical characters of osmiridium. Both identi-

fications were incorrect. Green micaceous schists were mistaken for serpentine and titaniferous iron ore for osmiridium.

Although these reports could not be substantiated, it has been found that a belt of serpentine extends from the northern end of this plain at the Gordon River for over a mile along the eastern flanks of Hamilton Range. Unfortunately the river was at full flood and unfordable at the time of the writer's visit, and in consequence the reports could not be verified. This occurrence is of the greatest importance, and is worthy of the closest investigation.

Boyes River Area.

Osmiridium, with its parent serpentine, has been observed by prospectors on the east bank of Boyes River, west of Denison Range. The grainsize is small, and the habit is flaky, and consequently unsuitable for the chief commercial uses for which osmiridium is in such great demand. The occurrence here is not extensive, and is similar in every other respect to those in neighbouring areas, and does not warrant on elaborate description.

From the foregoing account it may appear at first sight that the results of the expedition are somewhat disappointing, and that this region is never likely to become an effective producer of osmiridium. The paucity of these deposits compared with the rich concentrations in the great fields of the Western District is directly proportional to the sizes of the serpentine outcrops here and there. Moreover, in the latter localities erosion has removed enormous masses of serpentine, from which the osmiridium content has been set free and collected in the beds of adjacent streams, whereas in this locality denudation has not been carried deep enough to expose large areas of this rock.

From the economic viewpoint these deposits, with the possible exception of that to the east of Hamilton Range, are comparatively unimportant. The occurence, however, of the parent serpentinised intrusives so far south is of more than scientific interest, and their closer investigation may lead to the discovery of deposits other than those of the osmiridium group.

Spero River and Birch's Inlet.

A belt of serpentine outcrops on the south-east bank of the Spero River about 12 miles south of Point Hibbs, and, according to the reports of prospectors, this is the southern

PLATE X

GEOLOGICAL SKETCH MAP OF GORDON DISTRICT

Photo Algraphed by John Vail Government Printer Hobart Tasmania

projection of the Birch's Inlet body. The outcrops are not very extensive, and the known deposits of osmiridium are neither large nor rich. At the Spero the serpentine is the yellowish-green derivative of peridotite, while the Birch's Inlet rock is largely altered pyroxenite, and of a dark-green colour.

It may be mentioned here that osmiridium occurs in the creek flowing through Harris' Reward claim near Lynchford, and it is doubtfully reported from Conglomerate Creek above the falls, near Gormanston.

Salisbury District.

The occurrence of osmiridium in the Salisbury District has been known for many years. No serious attempt has been made to explore this serpentine belt, nor has there been an official examination of its osmiridium resources. There are decided possibilities in this area, and it is worthv of very careful attention.

CHAPTER II.

Mining Methods.

The methods employed in mining and washing the alluvial gravels in the osmiridium districts are of the most primitive character. The process varies according to the nature of the deposit, and the preference of the individual. Some miners prefer to work singly, while others find it convenient to work in pairs or in parties of three or more. As is only natural, the shallow gravels in steeply-inclined creeks, being so easily accessible and cheaply worked, are the first resources to be tapped. The nature of this work tends to create a class of fossicker who, equipped only with pick, shovel, axe, and dish, leads a nomadic existence, continually moving on from place to place in search for richer pay-dirt. The more ambitious miner has now turned his attention from these depleted shallow gravels to the larger terrace deposits and the more extensive river gravels. The miner's complain that the prospector's claim of 50 yards square is too small to warrant the heavy initial expenditure in time and money requisite for preparatory work, in order to attack the deposits to the best advantage. This disability could be obviated somewhat by the grouping of contiguous claims, and their co-operative exploitation by the owners. Certain of these extensive low-grade deposits, which cannot be worked successfully by small parties of miners, must ultimately pass into the hands of mining companies capable of operating them systematically. A more serious drawback is the lack of an adequate water-supply. Even during winter months, when there is an almost continuous rainfall, the local supply is inadequate for hydraulicing purposes, and costly conduits are necessary to convey additional supplies to the working faces.

In deep wash, where the values are contained in the bed-rock and the immediately overlying gravels, tunnels are driven to the boundary of the claim, headings are then driven at right-angles thereto, and the whole ground is blocked out from the back towards the entrance. The pay dirt is washed in cradles or in sluice-boxes, and the concentrated gold and osmiridium is finally cleaned by panning off the lighter gangue. Wing-damming is resorted to in the river beds in order to divert the water to one side, while the material on the other is being excavated. A

river diversion method of a quite different character has been adopted by Wood and party, of Savage River. These operators have been granted a 40-acre lease of a section of the river-bed, which cannot be exploited in the ordinary manner. In this case the river at a sharp bend has been diverted from its channel through a tunnel cut in at base-level. Wherever the conditions are suitable this method should be adopted.

In the deep river gravels and terraces dredging and hydraulicing methods of recovery will be employed, and there are extensive fields for such enterprise.

The pockety nature of osmiridium deposits in the rock must always prove a serious obstacle to their successful exploitation. There are, however, certain features in bodies of this type which provide indications of value to the operator in aiding the search for successive " makes " of ore. It is frequently found that the small pockets exposed in planes outcropping at surface when followed to a depth of a few feet abruptly peter out without showing direct evidence either of their continuance in depth or their probable recurrence in some other part of the plane. The only indications of the possibility of their recurrence, either along the course of the plane or at a deeper level, are the gradual divergence of the enclosing walls and the presence of its congener chromite. Talc and limonite, the ultimate decomposition products of olivine, usually constitute the rest of the filling material, but their occurrence is of no significance in this respect. A small body of osmiridium exposed at surface might become exhausted within 10 feet, and sinking might proceed on the plane through many feet of barren rock before the next deposit is encountered.([16]) It is considered, however, that the convergence and divergence of the walls of the planes along the strike and also along the dip will be found to take place at fairly regular intervals, and advantage of this fact may be taken in the design of future operations.

It will be perceived from the foregoing that the exploitation of osmiridium deposits is often attended by much uncertainty, and their sporadic occurrence precludes the possibility of forming an approximate estimate even of their extent and value.

It seems feasible to expect that, in sharply defined, continuous planes such as those containing osmiridium

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([16]) See plate III., page 36.

deposits in the Mt. Stewart area, the ordinary methods of lode mining may prove the most suitable means of exploitation. In the event of one of such methods being adopted the operators may find it convenient to stope out the barren portions also even when the walls have come together.

In some cases these methods cannot be applied, and excavation by quarrying will prove preferable.

Prospecting for Osmiridium.

Although there are alluvial deposits in the valleys of the large rivers sufficient in extent to provide employment for a large number of men over a long period, the easily accessible deposits in the smaller channels are nearly worked out. The depletion of the latter deposits has been hastened by the influx of the river diggers during the winter months when the rivers are in flood. With the decline of alluvial mining in these areas the prospector turned from the creek beds to find the source of the osmiridium in the serpentine rock on the hills. He believed the osmiridium came from lodes, and this opinion is held by many even to this day. He sought out ironstone cappings, and pinned his faith to all the phenomena indicative of lode formations. The occurrence of long lines of secondary chalcedonic silica and limonite on Bald Hill was seized upon as proof of the lode origin of the mineral and much time and energy was wasted in the endeavour to discover payable deposits in these formations. It is reported that a speck of osmiridium was found actually in chalcedony or attached to it, but this, probably, is due to accidental inclusion from the serpentine wall-rock, which is known to contain the mineral. It is evident that the solutions from which the chalcedony was deposited found their way into structural planes containing irregularly distributed pockets or "schlieren" of osmiridium, and that, although the supposed lode is barren, the so-called wall-rock may contain rich streaks. In this way it may happen that these chalcedony-limonite bodies indirectly indicate the presence of the mineral in the neighbouring serpentine, although actually they have no significance whatsoever.

Since the discovery of osmiridium in the parent rock by Thos. Pursell, W. Caudry, and Fenton brothers, in 1912, a great deal of time has been spent in the search for payable deposits in place. That the efforts of these and other prospectors have not been entirely successful from an

economic viewpoint is not surprising, nevertheless the information revealed by their operations is of very great scientific value. In order to provide safe criteria for the guidance of prospectors in future explorations, all available information has been carefully sifted, and the results are now placed before them. The mode of occurrence of the mineral in the form of "schlieren" in structural planes developed in peridotites and pyroxenites confined to definite positions in the igneous complex has already been fully discussed. It has been pointed out also that the richest accumulations occur towards the basal margin of the intrusive basic rocks. This limits the distribution considerably, and leads one to suppose that systematic exploration will reveal payable sections of rock.

After having established the presence of osmiridium in an area, the gullies leading from the serpentine belt should be carefully panned, and any material obtained should be traced up to its source. In this rock the prospector should seek for lines of differentiation or structural planes. These are frequently inconspicuous, and can be recognised only by careful examination. Their trend is always parallel to the margin of the intrusive rock. It may be mentioned here that lateral joints connecting groups of planes sometimes contain "metal" values. Although the largest deposits of osmiridium are found associated with chromite and limonite in these joints or planes isolated nuggets and disseminated particles have been observed in the solid rock. The abundance of chromite in the nuggets would lead one to search first of all for this mineral, but its presence is not necessarily indicative of osmiridium, as chromite occurs in some places where osmiridium is entirely absent, and *vice versa*. Hundreds of specimens of serpentine in which the contained chromite is abundant were carefully examined with the lens, and without exception it failed to reveal osmiridium. However, chemical tests showed in some cases fairly rich values in specimens obtained near the planes.

It is only after long experience in the recovery of osmiridium that the extremely erratic nature of its occurrence and distribution is fully realised. The value of a block of ground cannot be arrived at by sampling. Its approximate value may be determined to a certain extent by cutting trenches across the body and submitting the whole of the material broken to treatment, but even then rich pockets may be passed. For instance, large samples of serpentine were cobbed, crushed, and panned, but without discovering the smallest trace of osmiridium. These

samples of solid rock were taken from several of the most important prospects in the Heazlewood, Mt. Stewart, and Wilson River districts at points within a foot or two of structural planes known to contain rich pockets.

Having all these facts in mind, the question arises: Can these deposits be profitably exploited? Of course, the market price of osmiridium is the most important factor, but there are many other considerations to be taken into account in arriving at the precise value of any particular deposit, and only by actual test on a large scale can it be proved whether or not it is payable.

In answer to the question, where is the most likely place to prospect? the following localities may be mentioned:—On the north-western fall of Bald Hill extending from the 19-mile in an eastward direction, and passing under Basalt Hill; in the valley of Loughnan Creek in the Mt. Stewart area; along both margins of the intrusive serpentinised rocks, but especially on the south-western and south-eastern sides, in Wilson River district. North of Nineteen-mile Creek it is probable that other outcrops of osmiridium-bearing rocks will be found, and along the road south of Luina is an outcrop of peridotite which may contain the mineral. These are some of the most favourable localities for deposits of osmiridium in place. In addition there are several large undeveloped alluvial deposits in these districts, notably on the east side of Huskisson River, in the lower Savage, and in the lower Whyte River.

The Concentration of Osmiridium.

The separation and concentration of osmiridium and gold from alluvial and detrital materials consisting essentially of sand, gravel, and decomposed serpentine, can usually be effected by washing. If the gangue materials are soft and friable this is a simple operation; if the "wash" is cemented together or clayey it will require crushing or puddling before washing. On a small scale the metals are separated from the lighter gangue by means of a pan or dish. The barren overburden is first removed, then the bottom wash, the scrapings from cracks, and several inches of the soft bedrock is set aside for dishing. As a very large proportion of the osmiridium is deeply embedded in the basal rock the necessity for the exercise of care in cleaning up the bottom is evident. This method is employed only when the water-supply is poor. On the average the quantity of material dealt with by one man in a day is 30 dishes full.

Cradles are sometimes used, and by this means at least twice the quantity is handled.

Where water is available in sufficient quantity the sluice-box is generally preferred. With this plant two men can wash several tons of material in a day. A certain loss is sure to occur in sluicing, but it is a very simple and cheap method of handling a large quantity of material. The ground sluice is employed in places where it is difficult to construct wooden sluice-boxes, but in any case a small box is always used in the final clean-up. This method is almost always employed on the Tasmanian fields.

It may be mentioned here that appreciable amounts of osmiridium and gold are lost by attempting to sluice in boxes set at insufficient pitch. With little water and the small, narrow boxes in general use a pitch of 8 inches in 12 feet is necessary, and in extreme cases it may be convenient to increase the pitch to 1 in 12.

It is essential, in order to effect a complete recovery, to keep the ironstone rubble in motion so that the osmiridium may settle to the bottom of the box. Frequently it is noticed that operators allow the rubble to set in a compact mass through which the metal cannot penetrate.

If the conditions are suitable for hydraulicing under pressure, low-grade deposits, otherwise unpayable may be exploited successfully. In this operation a jet of water flowing through a nozzle under pressure is brought to bear on a deep face of alluvial material, which is broken down and carried into sluices, where the metals are caught and separated from the gangue as before. In exceptional cases this method has been adopted here.

The alluvial ground in the deep-water stretches of the rivers can be treated only by dredging. The lower part of the Savage River, and perhaps even the Pieman, may contain payable deposits, and, although the osmiridium and gold are fine-grained there, these grounds are worthy of careful attention. In 1899 long stretches of Savage River above its confluence with Nineteen-mile Creek were leased to a Melbourne syndicate for dredging purposes, but no actual attempt was made to exploit the river wash by this means. The difficulties encountered in dredging are rather formidable. In the shallower reaches the river bottom is strewn with large boulders and encumbered with trees. Again, the larger part of the osmiridium and gold is deeply embedded in the basal rock, which consists of soft, partly decomposed schists, and a special type of dredge is required for its recovery.

The separation of osmiridium from serpentine rock is very easily accomplished, owing to the great difference between the specific gravities of this alloy and the minerals composing the gangue. Again, the serpentine gangue rock is very soft and easily crushed, while osmiridium, although hard, is found usually so finely divided that it does not require further comminution. In fact, the sole object to be aimed at is to release the metals from the gangue without damage. In effecting this result it is necessary to reduce the gangue to the grainsize of the osmiridium.

It is evident from the foregoing that a pulverising plant is not required. The reduction may be effected by the use of an ordinary jaw-crusher and two sets of rolls. The separation of the metals from the crushed material is then made by means of the usual concentrating appliances. In order to test any particular deposit without incurring undue expenditure in plant, boxes and strakes may be substituted for mechanical concentrators.

CHAPTER III.

Status of the Osmiridium Industry.

THE WORLD'S SUPPLY AND PRODUCTION.

To-day Tasmania, Russia, Colombia, and Papua are the four principal osmiridium-producing countries of the world, and of these the first mentioned is by far the most important. In no other country are there deposits so rich that the mineral becomes the sole object of quest. Moreover, these are the only occurrences *in situ* in a quantity at all approaching what is suggestive of commercial value. In these respects the occurrences in Tasmania are unique. It must be mentioned, however, that the foregoing remarks apply only to the production of " free " osmiridium, for this mineral in alloy or in mechanical association is a constant and appreciable constituent of crude platinum. In fact, fully nine-tenths of the world's supplies of iridium, osmium, rhodium, and palladium come from this source. But as iridium and osmium are such desirable constituents of commercial platinum, upon which they confer special qualities, only a very small portion of this potential supply finds its way into the markets in the unalloyed condition. The mineral in Tasmania, unlike that found in any other country, occurs always in the free state, and the platinum associate is very rare. The universal association of the metals of the platinum group and their employment in alloy in the arts and sciences precludes the possibility of their separation in the discussion of the economic situation. It has been found necessary, therefore, to give statistical information concerning them all, so that a true conception may be formed of the present status of the industry.

The appended table gives the production of osmiridium in Tasmania for the last eleven years:—

TABLE I.

Year.	Quantity. Ounces, Troy.	Average Price per Ounce (Local).	Value.
		£	£
1910	120·00	4·42	530
1911	271 88	4·37	1188
1912	778·77	7·37	5742
1913	1261·65	9·52	12,016
1914	1018·83	9·89	10,076
1915	247·05	6·40	1581
1916	222·15	8·55	1899
1917	332·08	14·75	4898
1918	1606·74	27·90	44,833
1919	1669·72	23·73	39,614
Jan. to June, 1920	1093·12	38·09	41,642

Prior to 1910 no official records of the output were made, but since that time the Department of Mines has kept a strict account of the production from the several fields. A little osmiridium, of which no record is received, is still taken out of the State and sold direct to foreign buyers.

A survey of the figures contained in the above table shows that production follows the rise and fall in price. There was a gradual advance in production up to the outbreak of war in 1914; thence until 1917 the output was greatly reduced. Since that time, however, a wonderful recovery has been made, and this year will be signalised by an extraordinary advance both in production and value. In March last the local price reached £42 10s. per oz.

The very great demand, and the consequent high price offered, for the Tasmanian mineral are due to the dearth of "point metal" in other countries. Point metal is so called because of its use in the tipping of gold nibs for fountain-pens, for which purpose the mineral produced here is so admirably adapted. The price obtained for point metal is greatly in excess of that obtained for the ordinary fine-grained material; but the actual value cannot be definitely arrived at, as it is determined by negotiation between seller and buyer. Probably the ultimate value at the present time is not less than £50 per oz.

The value of the material of fine grainsize is governed by the fluctuations of the platinum market, which, in turn, was until recently, controlled by a body of financiers in Paris. It follows that so long as the demand for point metal continues, the industry in Tasmania will remain in a flourishing condition. Up to the present time no satisfactory substitute has been found for osmiridium in its employment in the manufacture of fountain-pens. The instability of the market has heretofore greatly militated against the systematic development of the industry, and has had a retarding influence on production. In the event of a serious fall in price, following a glut in the market, many of the poorer prospects will become unpayable, and production from others will suffer in like measure. Concerted action might be taken by producers in order to regulate the price by withholding supplies until the market has recovered, but such a drastic step should not be undertaken before ascertaining the true relation of the local output to that of competing countries. At the present time the demand is greater than the supply, and the market is buoyant.

Table II.

Imports of Allied Platinum Metals into the United States for the Years 1916 to 1918:—

Year 1916.

	Ounces, Troy.	Average Price per Ounce.	Value.
		£	£
Iridium	3346	15·61	52,230
Osmiridium	414	8·64	3592
Osmium	...	...	...
Palladium	6513	9·05	58,939
	Year 1917.		
Iridium	3619	21·80	78,891
Osmiridium	259	20·47	6137
Osmium	400	12·16	4867
Palladium	1239	19·71	24,415
	Year 1918.		
Iridium	1106	23·79	26,309
Osmiridium	427	22·60	9650
Osmium	...	...	...
Palladium	240	31·99	7678

Referring back to Table I. it will be noticed that the average price of osmiridium in Tasmania was £14.75 in 1917. This compares unfavourably with the purchase-price (£20·47) in that year in the United States. But in the following year the local average price was £27.4, while the average in America was only £22·6. This apparent anomaly is not difficult of explanation. Tasmanian point metal is in such great demand that it commands extraordinary prices, and its value is determined by negotiation, and not by current rates for crude metal. This does not explain, however, the low value of the metal in 1917, which was 30 per cent. under that paid for crudes.

The only country in Australasia likely to become a serious competitor with Tasmania in supplying the world's requirements of coarse-grained metal is Papua. At the present time, so far as can be learned, the output does not exceed 100 oz. of good-grade metal per annum, but an indication of the potentialities of the several districts where it is known to occur may be gathered by reference to the production from the Yodda goldfields, in the north-

eastern districts. In 1904 a well-known gold-buyer had in his possession over 100 oz. of osmiridium obtained from that area. The material of this parcel consisted of pieces of point metal selected from a concentrate of varied grain-size. Accompanying gold and osmiridium in these river gravels platinum is found in appreciable amounts.

No attempt has been made yet to demonstrate the precise extent and value of these deposits, but they occur over a very wide area, and are evenly distributed.

In New South Wales osmiridium constitutes 5 to 10 per cent. of crude platinum concentrates. The fields in which these minerals occur are never likely to become effective producers of osmiridium, but their output of platinum is sufficient for present local requirements.

In the vicinity of Byron Bay, Victoria, the mineral occurs in such a highly comminuted condition that it cannot be profitably recovered from the black sand in which it is contained. The other occurrences noted are unimportant.

In arriving at the production of other countries from official statistics great difficulties are encountered owing to the inclusion of osmiridium under the comprehensive heading "platinum." No attempt is made in the official returns to differentiate between "free" osmiridium and that chemically combined or mechanically involved with platinum. In consequence of this it is impossible to arrive at even an approximate estimation of the production of free osmiridium in foreign countries and no accurate figures concerning the output of combined metal are available for purposes of comparison. The universal association of the metals of the platinum group, and their frequent employment in alloy one with another in the arts and sciences, precludes the possibility of their separation in the discussion of the economic situation. It has been decided, therefore, to give statistical information concerning them all.

For the purpose of this report the figures quoted are compiled largely from statements appearing in "The Mineral Industry."

According to a Russian authority the output of that country has dwindled from 153 oz. of free osmiridium in 1904, to $4\frac{1}{2}$ oz. in 1911. But by far the larger portion of the total production is obtained from the treatment of platinum residues, of which unfortunately no definite records of late years are available. In the crude platinum obtained in the Ural Mountain districts the platinoid

metals constitute 83 per cent. of the material, and of this amount iridium, osmium, rhodium, and palladium, together form 4 to 6 per cent. Of the 17 per cent. of the remaining residual material, consisting largely of chromite and sand, fine-grained osmiridium constitutes one-twelfth.

As the normal output of Russia in pre-war time was, approximately, 250,000 oz. of crude platinum per annum, it is easy to see how completely the production of this country dominates the markets of the world, both as regards pure platinum and iridium and osmium as well.

The Russian official figures are far from correct, for in addition to the recorded output, there is a great deal of metal that is produced and marketed surreptitiously to avoid the payment of the Government tax. The quantity thus mined and disposed of through irregular channels is not so great now as formerly, as most of the mines are in the hands of companies operating on a large scale.

The production of platinoid metals in Russia since the outbreak of war has shown a progressive decrease.

The increased demand for platinum, coupled with the almost total cessation of the Russian supply of this metal, stimulated production in Columbia, where the alluvial deposits of the Choco River, and in the basins of the San Juan and Condoto Rivers were actively exploited. Since 1910 the output has shown a steady and progressive increase, and when the several companies recently organised commence operations this country will supply a large portion of the deficit in stocks. Many large dredging plants are being erected by these companies, and others are preparing to attack new fields, which apparently show good prospects of the platinoid metals and of gold.

Two analyses of platinum from Colombia are interesting, as showing the difference in allied mineral contents. The first sample was of 15,460 oz. of platinum mineral, and produced—

5·21 oz. platinum sponge.
4·47 oz. iridium.
0·47 oz. gold.

The second sample, comprising 6200 oz. of platinum-iridium mineral, gave—

3·36 oz. platinum.
0·11 oz. gold.
0·04 oz. iridium.
2·16 oz. osmiridium.

Table III.

Value of Platinum Raised in the Principal Producing Countries during the Decade 1909-1918.

Year.	Russia.			United States.		Colombia.		Canada.		Australia.		Average Quotations, Pure Platinum.
	Official Ounces, Troy.	Actual Ounces, Troy.	Value.	Ounces, Troy.	Value.	Ounces, Troy.	Value.	Ounces, Troy.	Value.	Ounces, Troy.	Value.	
			£		£		£		£		£	£
1909.	190,087	275,000	1,370,000	638	3190	8000	...	100	...	440	...	5·18
1910.	176,334	300,000	1,800,000	1025	6983	10,000	...	50	...	332	1418	6·77
1911.	187,008	280,000	2,450,000	940	8178	10,000	...	50	...	470	2999	8·98
1912.	177,596	300,000	2,725,000	1005	9156	11,750	103,164	30	...	652	4131	9·49
1913.	173,642	275,000	2,400,000	1484	...	15,000	...	158	...	442	...	9·35
1914.	156,775	241,200	1,948,000	570	...	17,500	...	18	98	221	...	9·40
1915.	119,789	124,000	1,080,000	742	...	18,000	121,500	236	2211	303	...	9·82
1916.	78,682	90,000	1,400,000	750	...	25,000	270,000	15	120	222	...	17·37
1917.	...	50,000	900,000	605	8744	32,000	432,000	57	765	259	2072	21·42
1918.	...	...	...	...	...	35,000	513,000	39	512	...	...	22·07

Note.—In addition to the output of free platinum the Canadian production is largely increased by the Sudbury mines, in which platinum and palladium are found in appreciable quantities.

Summarising the foregoing it is seen that so far as point metal is concerned Tasmania may be relied upon to meet requirements for many years to come. Not only are these deposits comparatively rich, but they are far more extensive than is generally believed, even by those engaged in their exploitation. There remain untouched enormous accumulations of osmiridium- and gold-bearing gravels, which, at existing rates would pay handsomely if proper appliances were used in their treatment. As the world's supplies of platinum minerals are far below the demand, there can be no doubt that the high prices offered to-day will be maintained. The annual consumption of platinum and its associates amounts to 325,000 oz. The production in pre-war time was insufficient to meet this demand, and the deficiency was made up by the purchase of scrap metal. At the present time it is quite impossible to arrive at a close estimation of the world's production, and it would be hazardous to speculate even on the approximate output of the principal producing countries. It is quite certain, however, that substitutes for these metals must be employed where possible in order to obtain adequate supplies for industries in which they are indispensable. The outlook for the future is decidedly encouraging, and operators need have no fear of a serious fall in price. In fact, the shortage is so great that it is now proposed to place these metals under international control, by which the world output will be apportioned, according to the requirements of the respective nations.

CHAPTER IV.

Osmiridium in Other Countries.

New South Wales.

Osmiridium has been reported from several districts in New South Wales, but nowhere in that country has it been found in commercial quantities.

([17])In 1885 F. A. Genth described the occurrence of osmiridium associated with cassiterite, native copper, gold, and platinum in some sand from the Aberfoil River. He says: "The so-called iridosmine seems to be present both as nevianskite in tin-white, flat scales and as siserskite in greyish-white or lead-coloured scales. Some of the scales are indistinct hexagonal plates, but mostly have an irregular shape." Samples of the platinum from this locality contained as much as 30 per cent. of osmiridium.

Osmiridium has been authoritatively identified in the gem-sand at Bingara, Mudgee, and Bathurst; in the beach sands of the northern coast. In some cases, as for example in the beach sands of Ballina, the osmiridium and other platinoid metals amount to as much as 40 per cent. of the platinum, or about 28 per cent. of the whole metallic content. Small samples of the crystallised mineral, purporting to come from the Dalmorton district, have been received at the Mining Museum, Sydney. It is reported also, on competent authority, from Barnet River district. No analyses of the mineral from this State are available.

The Fifield area is the chief source of platinum in New South Wales.

Victoria.

In Victoria, osmiridium has been found near Foster, and at Waratah Range, South Gippsland. It is reported that it has been found with gold in black beach sand at several points on the coast of Victoria. At Byron Bay vicinity the metal occurs in a highly comminuted condition which has baffled efforts to handle it commercially.

Papua.

([18])There are large belts of serpentine occupying certain portions of the older rocks about the Owen Stanley Range.

([17]) Procs. Amer. Phil. Soc., 1886, XXXIII, p. 31.

([18]) "Osmiridium in Papua" by Evan R. Stanley, F.G.S., Government Geologist.

They are associated with quartz and epidote veins and limestone in the northern extremes of the mountain chains in the Territory. These latter are intimately associated with the gold-bearing rocks, and can be traced into the upper waters of the Waria River. With the gold collected from the alluvial areas in the vicinity the osmiridium has been noted, and in some cases collected by the miners. The small quantity of osmiridium thus collected has been derived from the borders of the serpentine areas, which have become denuded, and spread sparingly into the gold placers.

The main belts of serpentines pass through the headwaters of the Waria to the Gira and Aikora Rivers, and follow up the right bank of the Yodda in the Ajula Kajala Range, thence through Oivi into the valley of the Kumusi. It is also met with in the Mugoni River and at Milne Bay. Osmiridium has also been found at Lakekama in the gold placers, and appears to be associated with a variety of serpentine called "verde antique."

Certain samples of gold reported to have come from the Brown River in the Central Division were found to contain small specks of osmiridium.

In the Yodda goldfield the osmiridium and gold have been shed from serpentinised peridotites consisting of olivine and rhombic pyroxene.

Russia.

The districts from which the platinum is produced are all within a comparatively small area. The Iss River and some neighbouring streams account for all the platinum that comes from the Shuvalof Estate. The claims on this river are mostly in the hands of the Société Anonyme d'Industrie du Platine of Paris. It is safe to say that 80 per cent. of the Ural platinum comes from the Iss and Pura Rivers. The Demidof or Tagis Estate, 50 miles to the south of the Iss, produces the bulk of the remainder.

The lower course of the Iss, some 25 miles, is mostly located under patented claims, averaging about 200 acres each. Most of these belong to the French company, but some are held by private individuals. The product of this river flat is estimated at a little over 1 dwt. per cubic yard, for an average width of 350 yards and with a depth of $3\frac{1}{2}$ yards from grass roots to bedrock. At the present rate of extraction the richest Iss deposits will be exhausted in ten years. There will remain in the 40 miles of its course

between 75 and 100 million cubic yards of the material in which there may be expected values corresponding to 20 per cent. of those previously extracted from the rich pay gravel.

The Tura River is a promising dredging field, and contains an immense and practically untouched store of alluvial platinum and iridium. The rights of the former owners, however, according to existing laws are an effectual bar to the development of dredging on this river.

The native source of the Iss platinum is dunite, a basic rock consisting essentially of olivine. The presence of platinum has been frequently determined by assay in this rock. No serious attempt has as yet been made to extract the platinum from the rock, and the general opinion is that it is not workable under present conditions, as the platinum does not occur in well-defined leads, but scattered irregularly through the rock in association with nodules of chromite.

Japan.

Osmiridium of good grainsize and quality is found in the platiniferous sands of the River Yubari. The extent and value of these deposits are not great, and the output has never exceeded 400 ounces per annum and is diminishing Only the high market rates ruling at present enable the miners to work at a profit.

Brazil.

In the province of Minas Geraes osmiridium and platinum occurs in gold drifts. Here also are found palladium-gold (porpezite) and rhodium-gold (rhodite). The osmiridium is very fine grained, but occurs in very extensive deposits and evenly distributed.

Colombia (South America).

Colombia is, after Russia, the chief producer of platinum. The gradual depletion of the Russian deposits and the stoppage of supplies from that source during the war have given a decided impetus to developments in the Colombia fields. The most important deposits are found in the Choco district, near the headwaters of the Atrato and San Juan Rivers. Here the alluvial platinum, osmiridium, and gold deposits are found in the beds of these small streams, which

rise in the Western Cordillera. Relatively little platinum occurs in the streams that flow east from the eastern side of these mountains; hence it is probable that the rocks from which this metal is derived are chiefly on the western slope. It is stated that specks of platinum have been found in the amphibolite rocks of the Condoto section, and specimens of a basic igneous rock, probably a peridotite, carrying platinum in small flaky particles, have been found in the Choco district. The Condoto is a small stream which flows into the headwaters of the San Juan River near the town of San Pablo. The gold washed from this small stream carries as much as 40 per cent. or more of its weight in platinum, which is always combined to a greater or less extent with iridium, osmium, palladium, and rhodium.

Sluicing is practised to some extent, but most of the platinum recovered is washed out by hand in dishes. However, in late years several dredges have been installed, and much more progressive methods are now in vogue.

Reports are current that the recent explorations and washing tests on the Cimarronas River have proved the deposits of platiniferous gravels to be much greater than was at first thought. It is said that this field is likely to prove more important than the districts on the Condoto and the tributaries at the headwaters of the San Juan, as it has more extensive dredging areas and better transportation facilities. Most of the gravel in the district carries gold, and in some cases it is said enough to pay operating expenses.

The recent organisation of the South American Gold and Platinum Co. promises a large increase in the production of platinum and its associates in Colombia. There can be no doubt that the best methods will now be introduced, and that mining operations will be carried on energetically. Owing to the disorganisation of industries in Russia there is some prospect that, with extensive mining in Colombia, that land may before very long displace Russia as the chief source of these extremely valuable and useful metals.

United States and Alaska.

The production of platinum metals from placer deposits in the United States amounts to about 700 ounces a year. It has not been possible to ascertain accurately the quantity of osmiridium produced. The crude platinum which is won in Trinity and Siskiyou Counties, North-Western California, and in Josephine, Coos, and Curry Counties, South-

Western Oregon, carries a little osmiridium. The crude platinum from Hay Fork of Trinity River, Trinity County, California, is probably the richest in osmiridium, and some lots have carried as high as 46 per cent. of this alloy.

The black sands of the Pacific Coast have recently received attention, but except in a few favoured spots they are unpayable. The reported occurrences in Arizona and Idaho were investigated and proved disappointing.

In connection with the prospects of mining for the platinum metals in Alaska, it is interesting to note that palladium is reported to have been obtained from the copper ore of the Salt Chuck Mine near Ketchikan in that territory; some platinum was also recovered. In the Koyuk district of Seward Peninsula more platinum was taken from gold placers in 1918 than during the previous year. A rich find is reported from the Gum and Nome areas on the Kaslo River.

Canada.

Small quantities of platinum and its associated metals are produced from the placer gravels of the Similkameen district of British Columbia. This, however, only covers a small part of Canada's platinum output, for it takes no account of the quantity secured by treating the matte from the great nickel-copper mines of the Sudbury district in Ontario.

In 1918 attention was directed to the known deposits in the Tulameen River, and active prospecting revealed payable gravels. There seems to be a good prospect of securing platinum from the Franklin Camp, Grand Forks, British Columbia. Here the metal is contained in copper ore at the rate of 2 to 3 dwt. per ton.

South Africa.

Platinum and osmiridium have been located in the Gwelo district, Southern Rhodesia. They occur in a gold-bearing reef in such small quantities as to have no economic significance.

Madagascar.

During the past few years small quantities of platinum have been found in the sediments of some rivers on the eastern coast of the island. It accompanies gold, in small rolled grains, the surface of which is sometimes polished, more rarely pitted; occasionally there is a covering of iron oxide. So far as is known these deposits are unimportant.

Platinum and Osmiridium Deposits in the Dutch East Indies.

Platinum and Osmiridium have been found in—(1) Java, and (2) Borneo.

(1) In the island of Java, platinum was found in minute quantities in the black gravels along the seashore near Tjilatjap (Banjaemas). In a communication of Maier (Natuurk. Tijdschrift voor Ned. Indie, XVIII., p. 395) he relates that in sand of Tjilatjap, together with gold some grains of a metal with a bluish silvery lustre were found. On account of an analysis he thinks this metal to be platinum. The value of these deposits has not been ascertained.

(2) In Borneo, according to Hooze (Jaarboek van het Mijnwezen, 1893) platinum is rather widely distributed, yet rarely is it found in really important quantities. Borneo platinum, on the peninsula Tana-Lavet, is always accompanied by gold and osmiridium, but the former in most cases greatly predominates in point of quantity. It is found also in the gold and diamond grounds of the "Afdeeling Martapoera." The metal is not generally recovered separately, but mostly together with gold. In outward appearance the platinum ores of this island differ considerably from those of the Urals. While the latter are found in the form of grains, the Borneo platinum consists of much worn small flakes or scales, and is seldom crystallised. Their blend is metallic, and the colour is silver white. Frequently there are found flakes, one side of which is of the colour of gold and the other platinum. These metals are found in alluvial and diluvial accumulations. Hooze states that one-tenth of the gold concentrates consists of platinum, and this more especially near the Goenoeng Lawak, where the grounds are richer in platinum than elsewhere. Dr. Verloop estimates the value of platinum in the diamond grounds about as high as that of gold.

The precious metal, as it is recovered from the diamond grounds, consists of rather pure platinum. An average of eight chemical analyses showed—

Platinum from 57·13 to 82·80 per cent.
Gold from 0·0 to 9·73 per cent.
Iron from 5·45 to 10·67 per cent.
Copper from 0·13 to 0·73 per cent.
The rest from 4·76 to 20·07 per cent.

Analyses of other samples of platinum ores showed their constitution to be—

Platinum from 58·0 to 75·0 per cent.
Osmiridium from 0·18 to 10·07 per cent.

It is noteworthy that the mineral laurite (Sp. Gr. 7, chem. comp. Ru. Os with 31·73 per cent. S.) was first detected here.

Krol, who inspected the diamond grounds of south-east Borneo in 1919, says that the richest diamond deposits, those near Tjampaka, at the same are richest in platinum. But there is also one gold placer without diamonds (the placer Rinaat, in the district of Pleiari), in which platinum occurs. In this placer the metal takes the form of small nuggets; in all other places it is found in scales and minute grains. It is considered that the source of the platinum must be looked for in the peridotite and serpentine rocks, but that the primary deposits are so poor and so small that even at a close examination they are overlooked.

According to Krol, the production of the whole Martapoera district is about 1 kg. of metal, with some 70 per cent. of platinum plus iridium.

CHAPTER V.

Commercial Applications of Osmiridium.

The application of osmiridium to industrial uses has extended greatly during recent years. In presenting this summary of its employment in the arts and sciences it may be mentioned that the information has been gathered from all available sources. An endeavour has been made to find out the cause of the recent augmented demand for the mineral, especially for that produced in Tasmania. The rapid progress made in the consumption of this shotty, well-crystallised "metal" is indicated by the buoyancy of the market, and the consequent increase in production.

Each of the subsidiary, as well as the essential, metals composing osmiridium has commercial applications, and the mineral itself is also employed in the arts without dissociation of the metals.

The principal application of osmiridium pertains to the manufacture of iridium-platinum ware, in which the iridium content ranges from 5 to 30 per cent. Such alloys are hard and difficult to work when containing from 10 to 20 per cent., and are not attacked by aqua-regia when the proportion of iridium exceeds 30 per cent. Nearly all platinum dishes, basins, and crucibles contain iridium. It forms an alloy with 9 parts of platinum, which is extremely hard, as elastic as steel, perfectly unalterable in the air, and capable of taking an exceedingly fine polish. This alloy has been employed in the production of bars for standard weights and measures, and for making electrodes to be used in corrosive liquids. An alloy of 15 per cent. iridium can be rolled to a thickness of 0·007 of a millimetre, and yet have sufficient resistivity to be used on an industrial scale in electrolytic work. A similar alloy is used for the wires employed in high temperature pyrometers. Iridium in the condition of sponge and oxide is used in photography and the ceramic art for obtaining a dense black, and by jewellers for obtaining black under white or transparent enamel. It is used also to a limited extent for surgical needles and for jewellers' drills. The substance phosphor-iridium was employed at one time as a substitute for osmiridium in tipping the gold nibs of fountain-pens. In this process it is first treated with phosphorus, which renders it more fusible and easy to

work. The phosphorus afterwards can be removed by heating the material in a lime crucible. Phosphor-iridium is said to be superior to steel for draw-plates in the manufacture of fine wire from gold, silver, copper, and iron. It has also been successfully employed for knife edges and bearings of very fine balances.

Osmium has been extensively used as a stain in microscopy and physiology. On account of its high melting-point it has been employed for the preparation of the filaments of incandescent electric lamps, but owing to its high cost tungsten is more generally used now. The "Osram" filament consists of an alloy of these two metals. Osmic acid and osmic chloride are such very poisonous gases that they may be employed in warfare. The substitution of osmium for iridium in the widely-used platinum alloy has been proposed. It has been found that alloys with 6 to 10 per cent. of osmium are as available for electric apparatus as those with 15 to 25 per cent. of iridium. The platinum-osmium alloy, while it has equal ductility, resists the action of acids better than platinum-iridium. Osmiridium in the coarse-grained form, in which it generally occurs in Tasmana, is used almost exclusively for tipping the points of gold fountain-pens. The mineral here is usually the rounded or shotty kind, so much sought after by manufacturers. The requisite qualities are a rounded shape, medium grainsize of particles, and compactness. There is a tendency in some specimens to break into thin flakes owing to the perfect basal cleavage possessed by this mineral. Such specimens for this purpose are valueless. Crude material is separated into the different sizes required by sifting through brass sieves; finally, the best grains are picked out by hand, with the aid of a microscope. A much higher price is paid for the graded material than for the crude. Coarse metal may be reduced to point size by crushing in a mortar, the proportion of fines resulting from this operation being very small. Other things being equal, there is no reason why the siserskite variety should not be as suitable for pen-points as nevyanskite. In some specimens, however, the high proportion of iron seems to destroy the qualities required for this purpose. Inasmuch as it is unoxidisable and non-magnetic, osmiridium has been employed for the bearings of the mariners' compass, and for watch bearings. No suitable substitute for this alloy has yet been produced.

Rhodium alloyed with platinum (10 per cent. Rh.) is chiefly used for the thermo-elements employed in high-temperature determination. Pure rhodium is used to make crucibles and dishes for chemical purposes when the vessels are required to stand the action of acids.

Ruthenium has a very limited application in the arts. It possesses qualities which can be adopted to the manufacture of electric filaments. Mixed with zirconium carbide it is used in the zirconium lamp.

Palladium has its most extensive application in the manufacture of certain alloys for dental work. The metal is also used in watchmaking, for the circles of astronomical instruments having the advantage over silver for this purpose in that it is not blackened by exposure, and for soldering platinum metals. Palladium alloyed with silver has been suggested as a substitute for platinum for contact and spark points. Various percentage compositions are used for various requirements, 60 per cent. of palladium and 40 per cent. silver showing the greatest resistance to spark erosion. Alloys of palladium with gold and silver make good substitutes for the softer forms of platinum. An alloy of palladium and rhodium, in the proportions of 90 per cent. of the former and 10 per cent. of the latter is used in the jewellery industry.

Part III.

CHAPTER I.

Abstract from the Mining Laws of Tasmania.

"The Mining Act, 1917."

MINERS' RIGHTS.

Claims under Miners' Rights.—Definition of Claims under Miners' Rights.

14. A single claim shall be such a parcel of land as may by virtue of one miner's right be held for mining for gold or any other metal or mineral; and a consolidated claim shall be any number of such parcels of land, not exceeding ten, as shall have been taken possession of conjointly, or any number of such parcels, not exceeding ten, as shall have been amalgamated, except as hereinafter provided.

Mode of Marking-off, and Area of, Miners' Right Claims.

15. Miners' right claims shall be marked off in the form of a square, or as near thereto as practicable, and the area shall be as follows:—

A single claim, ½-acre, 50 yards by 50 yards.
A consolidated claim, of—
- 2 men's ground, 1 acre, 70 yards by 70 yards.
- 3 men's ground, 1½ acre, 85 yards by 85 yards.
- 4 men's ground, 2 acres, 98 yards by 98 yards.
- 5 men's ground, 2½ acres, 110 yards by 110 yards.
- 6 men's ground, 3 acres, 120 yards by 120 yards.
- 7 men's ground, 3½ acres, 130 yards by 130 yards.
- 8 men's ground, 4 acres, 139 yards by 139 yards.
- 9 men's ground, 4½ acres, 148 yards by 148 yards.
- 10 men's ground, 5 acres, 155 yards by 155 yards.

Provided where it is not practicable to mark off in the form of a square, the area shall be equal to one-half of an acre for each man's ground contained within the claim.

Claims Fronting the Sea.

16. Claims upon land forming a part of the seashore shall not exceed a frontage to the sea of 20 yards, nor extend more than 20 yards above high-water mark, and shall have no limit to the seaward side: Provided such claims shall be marked as hereinafter provided, at such angles only as shall be above high-water mark.

Miners' Right Claims—How Taken Possession of.

17. Any person intending to take possession of a miner's right claim shall, himself or by his agent, fix in the ground firmly at each angle of the claim, a post not less than 3 inches in diameter, and projecting above the surface not less than 3 feet, one of which posts shall be deemed to be the datum post, and shall be marked with three notches; and shall have affixed thereto a notice in the Form No. 5 in the Schedule No. 1 hereto, which shall be clearly visible, and shall cut at each angle of such claim a trench not less than 6 inches deep and 6 feet along each line, and in timbered or scrubby land shall mark the boundary-line so as to be clearly visible as aforesaid. The said notice shall have legibly written or printed thereon the words "Miners' Right Claim," and the following particulars, that is to say—the name of the person for whom the claim is marked off; the date of marking off; and the position of the notice upon the land, so that the position of the claim may be thereby distinctly determined, and the notice shall be properly maintained during the occupation of the claim. Any person for whom a miner's right claim is marked off shall, himself or by his agent, within 48 hours after the marking-off or as soon thereafter as practicable, lodge with or post in a prepaid registered letter to a Registrar of Mines, a notice of such marking-off in the form No. 6 in the Schedule No. 1 hereto, and shall, within seven days after the marking-off, lodge a similar notice at the nearest post-office, if there be a post-office within 10 miles. The claim of any person who fails to comply with this regulation shall be deemed to be abandoned, and may be taken possession of by any person as unoccupied Crown land.

A certificate under the hand of the Registrar of Mines, that he has received the said notice by marking-off, and stating the day and hour of its receipt, shall be *primâ facie* evidence of the particulars stated in the certificate.

Claims to be Worked.—Forfeiture.—Machinery to—Represent Labour.

18. Within 48 hours after the marking-off of any miner's right claim, the person for whom the same is marked off shall, himself or by his agent, commence mining operations thereon or in connection therewith, and one man at least shall be employed for every half-acre of the claim; and if such mining operations shall be at any time suspended, without good and sufficient excuse, for a period of 48 hours, the claim shall be deemed to be forfeited, and may be taken possession of as unoccupied Crown land. Provided that where steam or water power is used, each horse-power—and where horses are employed in draught or in driving machinery, each horse so employed—shall be computed as equal to one man.

Claims may be Registered.

19. The holder of a miner's right claim may apply to the Registrar of Mines for the district in the Form No.7 in the Schedule No. 1, for registration thereof, and the Registrar shall receive such application, and record the same in a book to be kept for the purpose; and after the completion of registration, as hereinafter provided, such claim shall not be liable to forfeiture as under Regulation 18, but shall be dealt with as hereinafter provided.

Fees to Paid.—Notice of Intended Registration.

20. The holder of a claim shall, with his application, pay to the Registrar an application fee of 2s. 6d., and such survey fee as is prescribed, and upon the receipt of the survey plan of such claim, the Registrar shall post a notice outside his office in the Form No. 8 in the Schedule No. 1 hereto, stating that he intends, on a certain day to be named in such notice, not less than seven clear days from the date thereof, to make registration of such claim, unless any objection thereto shall be made.

Objections.

21. Any person objecting to the registration of a claim shall, at any time after the receipt of the application and before the expiration of the period specified in the notice aforesaid, give notice in writing to the Registrar specifying the grounds of his objection; and the Registrar shall not register such claim until a warden shall have inquired into such objection, and directed such registration to be made.

Marks to be Kept Up.

22. The holder of any claim in respect of which application for registration has been made, or which has been duly registered, shall, during his occupancy of such claim keep the posts fixed and the marks and notices clearly visible, as prescribed in Regulation 17; and in default thereof such claim shall be forfeited on an order to that effect being made by a warden: Provided always that the warden may inflict by way of fine, instead of forfeiture, a penalty not exceeding Ten Pounds.

Registrar to Make Registration.

23. If, at the expiration of such period, no objection shall have been made, or if, after objection has been made, such objection is disallowed by a warden, the Registrar shall make registration of the claim upon the register kept for the purpose, and shall insert therein a full description thereof.

Certificates of Registration.

24. As soon as the registration of any claim is completed, the Registrar shall, upon receipt of the prescribed fee, issue to the person in whose favour such claim shall have been registered, a certificate in the Form No. 9 in the Schedule No. 1 hereto; and every such certificate shall describe fully and accurately the claim to which it relates.

Claims may be Amalgamated.—Mode of Amalgamating Claims.—Division of a United Claim.

25. Any number of adjoining registered claims (single or consolidated) not exceeding the area of ten single claims, may, by the Registrar, by amalgamation, be consolidated as one claim; and upon the application of the holders of such claims made in the Form No. 10 in the Schedule No. 1 hereto, and signed by the person interested therein, the Registrar shall forthwith amalgamate such claims as one claim; and shall record such amalgamation upon the register relating to such claims, under the proper date, and shall issue to the holders of such claim a certificate in the Form No. 11 in the said schedule: Provided always, that in the event of the holders of a consolidated claim agreeing among themselves to divide such claim, each such division shall be registered by the Registrar upon application signed by the persons holding such claim, in the manner provided by these regulations for the registration of such claims.

Transfers.

26. The registered holder of any miner's right claim may, in the Form No. 12 in the Schedule No. 1 hereto assign or transfer such claim to any other person being the holder of a miner's right sufficient to hold such claim; provided that every such transfer shall be signed by the parties thereto in the presence of some person or persons who shall attest the signature to such transfer; and upon the completion of such transfer the Registrar shall record upon the register relating to the claim so transferred the date on which the transfer shall have been made, and the name of the transferee, together with such other particulars relating to such transfer as to such Registrar may appear necessary, and shall issue to the transferee a duplicate of the transfer. The Registrar shall retain and file the certificate and transfer delivered to him as aforesaid.

Executors, Trustees, Guardians, &c., to be Registered.

27. The executors or administrators, or the receiver or trustee in bankruptcy, or the liquidator, or the guardians in infancy, or the committee of guardians in lunacy, or any person possessed of any claim, or the purchaser or purchasers under an execution of any claim, or the liquidator of any company may be registered for in respect of such claim; and the Registrar shall, upon production of the order or authority under which such executors, administrators, receivers, trustees, guardians, committee, or purchaser or purchasers, or liquidator as aforesaid claim to be registered, and on the production of a miner's right or miners' rights sufficient to hold such claim, register them or any of them named in such order or authority for or in respect of such claim so possessed or purchased as aforesaid.

Warden may Grant Exemption.—Notice to be Posted

28. Where it is desired to exempt any claim held under a prospector's licence or miner's right, as the case may be, from the prescribed conditions of labour, occupation or use, any application for that purpose shall be made by the holder of the said licence or right to a warden, who may, if he thinks fit, grant exemption under Section 37 of the Act, upon payment of the fee of Five Shillings; and

the applicant shall cause notice of such exemption to be posted, and kept posted, on some conspicuous part of the claim to which it relates during the term of the exemption.

Forfeiture of Registered Claims.

29. Subject to the provisions of the last preceding regulation, any miner's right claim in respect of which application for registration has been made, or any claim which has been duly registered, shall be liable to forfeiture, and may, by a warden, be forfeited, if full mining operations as prescribed by Regulation 18 are at any time suspended without good and sufficient excuse for a period of 48 hours. Provided always, that the warden may for the first offence inflict, by way of fine, in lieu of forfeiture, a penalty not exceeding Twenty Pounds.

Possession of a Forfeited Registered Claim.

30. When any claim in respect of which application for registration has been made, or any claim which has been duly registered, shall be liable to forfeiture, any person may apply to a warden to obtain adjudication of forfeiture, and possession of such claim; and the person who shall first apply to a warden in that behalf shall be entitled to possession of such claim if declared forfeited on his application.

Removal of Plant in Case of Forfeiture.

31. All provisions of these regulations relating to forfeiture and abandonment or removal notwithstanding, no person shall be entitled to take possession of any miner's right claim or prospecting claim in or upon which any plant, machinery, or engines, of a total value exceeding Twenty Pounds, may be placed or laid down without first obtaining the sanction of a warden, who may impose such reasonable conditions as he thinks fit with respect to any such plant, machinery, or engines.

Registration of Forfeited Claim.

32. When an order shall be made by the warden directing that any person named in the order shall be put in possession of a forfeited claim, the Registrar shall forthwith register such person for such claim in lieu of the person who shall have forfeited the claim.

Protection during Holidays, &c.

33. All claims, rights, and privileges shall be deemed to be protected while the holders thereof are attending elections of members of Parliament or of any public body, or necessarily attending any court of justice, or before a warden, and also during the following periods, viz:—From Good Friday to Easter Tuesday inclusive, on His Majesty's Birthday, from 22nd December to 5th January inclusive, and on any day or period of time proclaimed a public holiday or declared a holiday by a warden under Regulation 150.

Deserted and Abandoned Ground.

34. Ground which, having been held under miners rights as a registered claim, or under application for registration, shall have been unworked for a period of three months shall be deemed to be and shall be treated as ground absolutely deserted and abandoned, and may be taken possession of in the same manner as unoccupied Crown land; but this shall not apply to ground held under protection.

Warden may Authorise Water-races, Roads, &c.

35. The warden may, in his discretion, by writing under his hand, authorise any person being the holder of a claim to enter on any other mining tenement, and to make or cause to be made through, over, along, or across any part or parts thereof all such water-races, tail-races, drains, dams, sluice-heads, reservoirs, tramways, roads, tunnels, and other works as shall be necessary to enable such person to mine the claim held by him, and also to keep the same in proper repair and condition, and also to deposit all soil, stones, and substances which may be dug up or removed in executing any such works. The warden may, in granting any such authority, impose such terms and conditions as he thinks fit.

Claims in Excess may be taken by Another Person.

36. If any person marks off a claim larger than that regulations allow, the holder of the claim shall reduce his area to the proper limits by measuring from his datum peg, and

the excess may be taken possession of by any other person. Provided that if any shaft or works come within the area so taken possession of, the person so taking possession shall pay compensation to the original holder, to be assessed by a warden or any person or persons deputed by him in writing for that purpose, or the warden may, without ordering payment of any compensation, require the original holder of the claim to so mark it off as to include such shaft or works within the area of land allowed him by these regulations.

Warden to Reserve Roads, Footpaths, &c.—Penalty for Obstructing.

37. The warden shall have the power of reserving any roadway or footpath not exceeding Twenty feet in width required for the general convenience of miners through, over, or across any mining tenement or any Crown lands upon any mining field, and of causing the same to be marked; and any person who obstructs or injures such roadway or footpath shall forfeit and pay a penalty not exceeding Ten Pounds.

Claims Not Forfeited through Neglect of Servant, &c.

38. No claim shall be forfeited through the neglect or by the act of any hired servant, contractor, tributer, or tenant, if after seven days' notice in writing of such neglect or act to the owner or his agent, such claim shall be worked or otherwise dealt with in accordance with these regulations.

Sickness, Unavoidable Absence, and Failure of Water, &c.

39. No claim, area, right, or privilege shall be forfeited for any neglect the consequence merely of the sickness or unavoidable absence of any person, or of failure of water or other natural contingency.

Warden may Authorise Entry of Surveyor upon Claim.

40. It shall be lawful for a warden to authorise by writing under his hand any surveyor or other person, with or without assistants, to enter into and upon any mining tenement, and all mines, work, and buildings thereon and therein, and to view, examine, and survey the same, and

for that purpose to make use of any of the roads, ways, machinery, and works belonging to the said mining tenement.

Holder of Miner's Claim or Prospecting Claim to Remove Notice, &c., upon Abandoning Claim.

41. The holder of any miner's claim or prospecting claim shall, upon abandoning such claim, remove his notice and withdraw all posts or stakes from the ground.

Schedule No. 1.

Form No. 3 (Regulation 13).

Tasmania.

(Coat of Arms.)

No. Fee—

Place.

Date. 19 .

MINER'S RIGHT.

Issued to

under the provisions of "The Mining Act, 1917." To be in force until 31st December, 19 .

Officer Authorised to Issue.

Not Transferable.

Form No. 4 (Regulation 13).

Tasmania.

(Coat of Arms.)

No. Fee—

Place

Date. 19 .

CONSOLIDATED MINER'S RIGHT.

Issued to [*here insert manager's name*] [*here insert description and situation of registered claim*] under the provisions of "Mining Act, 1917." To be in force until 31st December, 19 , and to represent miners' rights

Officer Authorised to Issue.

Not Transferable.

Name.

Form No. 5 (Regulation 17).

MINER'S RIGHT CLAIM.

Name.

Date of marking off.

This notice is situate at [*here describe the position of the notice, such as at the north-east corner of the land or the south-west corner, as the case may be*].

Osmiridium Mining Leases.

The ordinary regulations dealing with applications for mineral leases apply to osmiridium.

The Governor in Council is not bound to grant applications although the applicant may have complied with the regulations; and the number and area of applications for leases, if thought desirable, may be reduced to prevent any one person or company obtaining a monopoly in the event of a discovery of osmiridium *in situ* being made.

Leases for river or alluvial claims will not be granted but leases woud be granted to work deposits or lodes occurring in the matrix or serpentine rock.

Regulatons under "The Osmiridium Act, 1919."

1. In these regulations the words "the Act" shall mean "The Osmiridium Act, 1919."

2. The application for an osmiridium buyer's licence shall be in the form contained in Schedule (1) hereto.

3. The application for a renewal of a licence under Section 7 of the Act shall be in the form contained in Schedule (2) hereto.

4. The notice to be served under Section 14 of the Act to the Secretary for Mines by any person who transfers osmiridium from this State, or disposes of it outside this State, shall be in the form contained in Schedule (4) hereto.

5. The statement to be signed by every licensee when forwarding his monthly return under Section 10 of the Act shall be in the form contained in Schedule (3) hereto.

6. Every licensee shall forthwith notify to the Minister in writing any change in the address of his place of business, and where he intends carrying on same, and shall be liable to a penalty not exceeding Five Pounds for every failure so to do.

Schedule (1).

"The Osmiridium Act, 1919."

(Section 4.)

APPLICATION FOR A LICENCE AS AN OSMIRIDIUM-BUYER

I, the undersigned, , of , hereby make application for an osmiridium-buyer's licence, authorising me to buy osmiridium under the provisions of "The Osmiridium Act, 1919."

(1) My name in full is—

(2) My business, trade, or calling is—

(3) The place at which business under the licence, if granted, will be carried on is situated at

Dated the day of , 192 .

(Signature.)

The Honourable the Minister for Mines.

Schedule (2).

"The Osmiridium Act, 1919."

(Section 7.)

APPLICATION FOR A RENEWAL OF A LICENCE AS AN OSMIRIDIUM-BUYER.

I, the undersigned, , of in accordance with the requirements of "The Osmiridium Act, 1919," and the regulations made thereunder, hereby apply for a renewal of the osmiridium-buyer's licence at present held by me.

Dated this day of , 192 .

(Signature.)

The Honourable the Minister for Mines.

Schedule (3).

"The Osmiridium Act. 1919."

(Section 10.)

MONTHLY RETURN BY LICENSED OSMIRIDIUM-BUYER

I, the undersigned, , of licensed osmiridium-buyer, hereby certify that the following sheets comprise a complete and correct copy of all entries made in the Osmiridium Register-book kept by me pursuant to the requirements of "The Osmiridium Act, 1919," and the regulations thereunder during the month of last past.

Dated at , this day of , 192

Licensed Osmiridium-Buyer.

The Secretary for Mines.

Schedule (4.)

"The Osmiridium Act, 1919."

(Section 14.)

NOTICE OF TRANSFER OF OSMIRIDIUM FROM THE STATE OF TASMANIA.

I, , of , in Tasmania, in compliance with the provisions of Section 14 of "The Osmiridium Act, 1919," do hereunder furnish particulars of osmiridium transferred by me from this State:—

Date when Transferred.	Whence Obtained.	To whom Forwarded.	Quantity.	Price Obtained.

(Signature.)

(Date.)

A. McINTOSH REID,

Assistant Government Geologist.

Launceston, 15th October, 1920.

GEOLOGICAL SURVEY OF TASMANIA.

LIST OF PUBLICATIONS.

BULLETINS.

No. 1.—The Mangana Goldfield, by W. H. Twelvetrees 1907

No. 2.—The Mathinna Goldfield, Part III., by W. H. Twelvetrees 1907

No. 3.—The Mt. Farrell Mining Field, by L. Keith Ward, B.A., B.E. 1908

No. 4.—The Lisle Goldfield, by W. H. Twelvetrees 1908

No. 5.—Gunn's Plains, Alma, and other Mining Fields, North-West Coast, by W. H. Twelvetrees ... 1909

No. 6.—The Tinfield of North Dundas, by L. Keith Ward, B.A., B.E. 1909

No. 7.—Geological Examination of the Zeehan Field, Preliminary Statement, by W. H. Twelvetrees and L. Keith Ward, B.A., B.E. 1909

No. 8.—The Ore-bodies of the Zeehan Field, by W. H. Twelvetrees and L. Keith Ward, B.A., B.E. 1910

No. 9.—The Scamander Mineral District, by W. H. Twelvetrees 1911

No. 10.—The Mt. Balfour Mining Field, by L. Keith Ward, B.A., B.E. 1911

No. 11.—The Tasmanite Shale Fields of the Mersey District, by W. H. Twelvetrees 1911

No. 12.—The X River Tinfield, by L. Keith Ward, B.A., B.E. 1911

No. 13.—The Preolenna Coalfield and the Geology of the Wynyard District, by Loftus Hills, M.Sc. ... 1913

No. 14.—The Middlesex and Mt. Claude Mining Field, by W. H. Twelvetrees 1913

No. 15.—The Stanley River Tinfield, by L. Lawry Waterhouse, B.E. 1914

No. 16.—The Jukes-Darwin Mining Field, by Loftus Hills, M.Sc. 1914

No. 17.—The Bald Hill Osmiridium Field, by W. H. Twelvetrees 1914

No. 18.—Geological Reconnaissance of the Country between Cape Sorell and Point Hibbs, by Loftus Hills, M.Sc. 1914

No. 19.—The Zinc-Lead Sulphide Deposits of the Read-Rosebery District, Part I. (Mount Read Group), by Loftus Hills, M.Sc. 1914

REPORTS.

RECORDS.

MINERAL RESOURCES.

JOHN VAIL,
GOVERNMENT PRINTER, TASMANIA.